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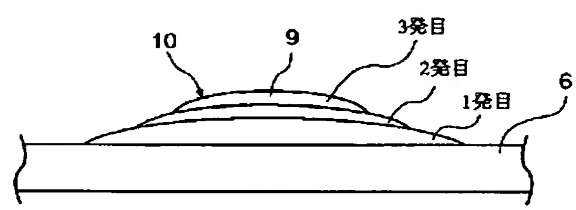
(54)【発明の名称】　液晶素子及びその製造方法及びスペーサー付き基板及びその製造方法

(57)【要約】
【課題】コスト上昇を招くことなく、表示品位に優れた液晶素子の製造方法を提供する。
【解決手段】一対の基板をスペーサーを介して対向配置し、基板間に液晶化合物を挟持してなる液晶素子の製造方法であって、一対の基板のうちの一方の基板６上に、スペーサー形成材料９を同一箇所に複数回に分けて付与して硬化させ、一対の基板の間隔を規定するスペーサー１０を形成するスペーサー形成工程と、一対の基板を、スペーサーを挟んで対向配置する配置工程と、対向配置された一対の基板間に液晶化合物を封入する封入工程とを具備する。



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【特許請求の範囲】

【請求項１】　一対の基板をスペーサーを介して対向配置し、該基板間に液晶化合物を挟持してなる液晶素子の製造方法であって、

前記一対の基板のうちの一方の基板上に、スペーサー形成材料を同一箇所に複数回に分けて付与して硬化させ、前記一対の基板の間隔を規定するスペーサーを形成するスペーサー形成工程と、

前記一対の基板を、前記スペーサーを挟んで対向配置する配置工程と、

前記対向配置された一対の基板間に液晶化合物を封入する封入工程とを具備することを特徴とする液晶素子の製造方法。

【請求項２】　前記スペーサー形成材料を同一箇所に複数回付与する場合に、２回目以降のスペーサー形成材料の付与量は、１回目の付与量より少なくすることを特徴とする請求項１に記載の液晶素子の製造方法。

【請求項３】　前記スペーサー形成材料を同一箇所に複数回付与する場合に、先に付与したスペーサー形成材料をある程度硬化させた後に、後のスペーサー形成材料の付与を行うことを特徴とする請求項１に記載の液晶素子の製造方法。

【請求項４】　前記スペーサーが形成される基板が、透明基板上に着色層を備えたカラーフィルタを用いて構成されていることを特徴とする請求項１に記載の液晶素子の製造方法。

【請求項５】　前記スペーサーが形成される基板が、画素毎にアクティブ素子を備えたアクティブマトリクス基板であることを特徴とする請求項１に記載の液晶素子の製造方法。

【請求項６】　前記スペーサー形成材料は、硬化性樹脂からなることを特徴とする請求項１に記載の液晶素子の製造方法。

【請求項７】　前記スペーサー形成材料をインクジェット方式により付与することを特徴とする請求項１に記載の液晶素子の製造方法

【請求項８】　請求項１乃至７のいずれか１項に記載の液晶素子の製造方法により製造されたことを特徴とする液晶素子。

【請求項９】　基板上に、スペーサー形成材料を同一箇所に複数回に分けて付与して硬化させることによりスペーサー付き基板を形成することを特徴とするスペーサー付き基板の製造方法。

【請求項１０】　前記スペーサー形成材料を同一箇所に複数回付与する場合に、２回目以降のスペーサー形成材料の付与量は、１回目の付与量より少なくすることを特徴とする請求項９に記載のスペーサー付き基板の製造方法。

【請求項１１】　前記スペーサー形成材料を同一箇所に複数回付与する場合に、先に付与したスペーサー形成材料をある程度硬化させた後に、後のスペーサー形成材料の付与を行うことを特徴とする請求項９に記載のスペーサー付き基板の製造方法。

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【請求項１２】　前記スペーサーが形成される基板が、透明基板上に着色層を備えたカラーフィルタを用いて構成されていることを特徴とする請求項９に記載のスペーサー付き基板の製造方法。

【請求項１３】　前記スペーサーが形成される基板が、画素毎にアクティブ素子を備えたアクティブマトリクス基板であることを特徴とする請求項９に記載のスペーサー付き基板の製造方法。

【請求項１４】　前記スペーサー形成材料は、硬化性樹脂からなることを特徴とする請求項９に記載のスペーサー付き基板の製造方法。

【請求項１５】　前記スペーサー形成材料をインクジェット方式により付与することを特徴とする請求項９に記載のスペーサー付き基板の製造方法。

【請求項１６】　請求項９乃至１５のいずれか１項に記載のスペーサー付き基板の製造方法により製造されたことを特徴とするスペーサー付き基板。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、カラーテレビ、パーソナルコンピュータ、パチンコ遊戯台等に使用される液晶素子及びその製造方法に関し、さらには、液晶素子の構成部材であるスペーサー付き基板及びその製造方法に関する。

【０００２】

【従来の技術】近年、パーソナルコンピュータの発達、特に携帯用パーソナルコンピュータの発展に伴い、カラー液晶ディスプレイの需要が増加する傾向にある。しかしながら、さらなる普及のためには、コストダウンが必要不可欠となっている。

【０００３】従来、液晶素子の製造方法としては、一対の透明な絶縁性基板であるガラス基板上にＴＦＴ（薄膜トランジスタ）のような液晶駆動用素子、或いはカラーフィルタのような着色用光学素子などを設けた後、透明電極及び配向膜をそれぞれ形成する。次に、透明電極及び配向膜が形成された一方のガラス基板面側の全面に一般に３～１０μｍ程度のシリカ、アルミナ、合成樹脂等からなる真球或いは円筒状の粒子をスペーサーとして分散させる。透明電極を対向させた状態で上記一対のガラス基板を上記スペーサを介して重ね合わせ、その間隙に液晶を封入することにより液晶素子が構成される。

【０００４】ところが、有効画素部では透明／遮光状態が表示状態によって変化するため、上記スペーサーを無色透明な素材で形成した場合には、遮光時に輝点として、また、黒色に着色した場合には透過時に黒点として観察されることとなり、表示品位が低下するという問題があった。

【０００５】上記問題を解決するために、特開昭６１－１７３２２１号公報、特開平２－２２３９２２号公報などに示されるように、配向膜に配向処理を行った後、感光性ポリイミドやフォトレジストを塗布し、マスクを通して露光することで有効画素部以外にポリイミドやレジストからなるスペーサーを形成するという方法が提案されている。これらの方法によれば、任意の場所に、任意の密度でスペーサーを形成することができるため、液晶を封入した際の液晶セルギャップの不均一性を改善できる。また、特開平３－９４２３０号公報には、有効画素部以外の領域の感光層上にビーズスペーサーを固定する方法が記載されている。
【０００６】その他にも、膜厚の大きなブラックマトリクスをスペーサーとする方法（特開昭６３－２３７０３２号公報、特開平３－１８４０２２号公報、特開平４－１２２９１４号公報等）、重ねた着色レジストをスペーサーとする方法（特開昭６３－８２４０５号公報）、ブラックマトリクス上にも着色パターンを形成し、スペーサーとする方法（特開昭６３－２３７０３２号公報）などが提案されている。
【０００７】
【発明が解決しようとする課題】しかしながら、上記各公報に提案された改善方法は、いずれもフォトリソグラフィーを用いた方法であるため、高価な露光機が必要であり、また現像などのウエットプロセスの導入により、製造ラインが長くなるという問題があった。
【０００８】また、上記各改善方法では、ラビング方法などにより配向処理を行ったポリイミド膜などの配向膜上に直接、感光性ポリイミドやフォトレジストなどを塗布し、露光後は不要部を溶剤などにより除去する必要がある。これらの工程は、上記配向膜に施された配向処理状態を著しく汚染、破壊してしまう場合があり、液晶セル内に注入された液晶の配向が不均一となる懸念があった。
【０００９】従って、本発明は上述した課題に鑑みてなされたものであり、その目的は、コスト上昇を招くことなく、有効画素部及び非有効画素部のいずれにもスペーサーによる表示上の影響が無く、表示品位に優れた液晶素子の製造方法及びそれにより製造された液晶素子を提供することである。
【００１０】また、本発明の他の目的は、液晶素子の構成部材であるスペーサー付き基板及びその製造方法を提供することである。
【００１１】
【課題を解決するための手段】上述した課題を解決し、目的を達成するために、本発明に係わる液晶素子の製造方法は、一対の基板をスペーサーを介して対向配置し、該基板間に液晶化合物を挟持してなる液晶素子の製造方法であって、前記一対の基板のうちの一方の基板上に、スペーサー形成材料を同一箇所に複数回に分けて付与して硬化させ、前記一対の基板の間隔を規定するスペーサーを形成するスペーサー形成工程と、前記一対の基板を、前記スペーサーを挟んで対向配置する配置工程と、前記対向配置された一対の基板間に液晶化合物を封入する封入工程とを具備することを特徴としている。
【００１２】また、この発明に係わる液晶素子の製造方法において、前記スペーサー形成材料を同一箇所に複数回付与する場合に、２回目以降のスペーサー形成材料の付与量は、１回目の付与量より少なくすることを特徴としている。
【００１３】また、この発明に係わる液晶素子の製造方法において、前記スペーサー形成材料を同一箇所に複数回付与する場合に、先に付与したスペーサー形成材料をある程度硬化させた後に、後のスペーサー形成材料の付与を行うことを特徴としている。
【００１４】また、この発明に係わる液晶素子の製造方法において、前記スペーサーが形成される基板が、透明基板上に着色層を備えたカラーフィルタを用いて構成されていることを特徴としている。
【００１５】また、この発明に係わる液晶素子の製造方法において、前記スペーサーが形成される基板が、画素毎にアクティブ素子を備えたアクティブマトリクス基板であることを特徴としている。
【００１６】また、この発明に係わる液晶素子の製造方法において、前記スペーサー形成材料は、硬化性樹脂からなることを特徴としている。
【００１７】また、この発明に係わる液晶素子の製造方法において、前記スペーサー形成材料をインクジェット方式により付与することを特徴としている。
【００１８】また、本発明の液晶素子は、上記の液晶素子の製造方法により製造されたことを特徴としている。
【００１９】また、本発明に係わるスペーサー付き基板の製造方法は、基板上に、スペーサー形成材料を同一箇所に複数回に分けて付与して硬化させることによりスペーサー付き基板を形成することを特徴としている。
【００２０】また、この発明に係わるスペーサー付き基板の製造方法において、前記スペーサー形成材料を同一箇所に複数回付与する場合に、２回目以降のスペーサー形成材料の付与量は、１回目の付与量より少なくすることを特徴としている。
【００２１】また、この発明に係わるスペーサー付き基板の製造方法において、前記スペーサー形成材料を同一箇所に複数回付与する場合に、先に付与したスペーサー形成材料をある程度硬化させた後に、後のスペーサー形成材料の付与を行うことを特徴としている。
【００２２】また、この発明に係わるスペーサー付き基板の製造方法において、前記スペーサーが形成される基板が、透明基板上に着色層を備えたカラーフィルタを用いて構成されていることを特徴としている。
【００２３】また、この発明に係わるスペーサー付き基

板の製造方法において、前記スペーサーが形成される基板が、画素毎にアクティブ素子を備えたアクティブマトリクス基板であることを特徴としている。

【００２４】また、この発明に係わるスペーサー付き基板の製造方法において、前記スペーサー形成材料は、硬化性樹脂からなることを特徴としている。

【００２５】また、この発明に係わるスペーサー付き基板の製造方法において、前記スペーサー形成材料をインクジェット方式により付与することを特徴としている。

【００２６】また、本発明に係わるスペーサー付き基板は、上記のスペーサー付き基板の製造方法により製造されたことを特徴としている。

【００２７】

【発明の実施の形態】以下、本発明の好適な一実施形態について、添付図面を参照して詳細に説明する。

【００２８】なお、本明細書においては従来公知のインクジェット方式についてインクの代わりにスペーサー素材を吐出するものを便宜上インクジェット方式と呼ぶ。

【００２９】図１は、本発明の液晶素子の製造方法の一実施形態の工程のうち、スペーサー付基板を形成するまでの工程を示す模式図である。本実施形態は、一方の基板を透明基板上に着色層と保護層を備えたカラーフィルタを用いて構成し、該基板上にスペーサーを形成する例である。図中、１は透明基板、２はブラックマトリクス、３は着色層、４は保護層、５は透明電極、６は配向膜、８はインクジェットヘッド、９は硬化性インク、１０はスペーサーである。尚、図１の（ａ）～（ｇ）はそれぞれ以下の工程（ａ）～（ｇ）にそれぞれ対応する断面模式図である。

【００３０】工程（ａ）

透明基板１上に、必要に応じてブラックマトリクス２を形成する。本発明において透明基板１としては、一般にガラス基板が用いられるが、液晶素子としての透明性、機械的強度等の必要特性を有するものであればガラス基板に限定されるものではなく、プラスチック基板なども用いることができる。

【００３１】ブラックマトリクス２としては特に制限はなく、公知のものを用いることができる。例えば、透明基板１上に形成したＣｒ等の金属や金属酸化物などの積層膜をパターン状にエッチングしたり、透明基板１上に塗布した黒色レジストをパターニングすることより、形成することができる。

【００３２】工程（ｂ）

透明基板上にカラーフィルタのＲ（赤）、Ｇ（緑）、Ｂ（青）の３原色の着色層３を形成する。本発明において着色層３の形成方法は特に限定されず、公知の技術が用いられる。例えば、顔料を分散した光硬化性樹脂組成物を用いた顔料分散方、基板上に成膜した樹脂被膜を染料を用いて染色した染色方、導電性基板上に通電しながら着色組成物を電着せしめることにより着色層を形成する電着法、印刷技術を応用した印刷法、熱転写技術を応用した熱転写法などが挙げられる。また、コスト面から考えると、１工程で３色の着色層を同時に形成しうるインクジェット方式を利用した方が望ましい。

【００３３】また、着色層３は、特に本発明に係るスペーサー１０を形成する基板側に設ける必要はなく、液晶素子を構成する一対の基板のいずれか一方に形成すればよい。

【００３４】工程（ｃ）

必要に応じて保護層４を形成する。保護層４としては、光照射または熱処理、或いはこれらの両方により硬化可能な樹脂層、或いは蒸着またはスパッタによって形成された無機膜等を用いることができ、カラーフィルタとしての透明性を有し、その後のＩＴＯ膜形成工程や配向膜形成工程等に耐えうるものであれば使用可能である。

【００３５】工程（ｄ）

必要に応じて透明導電膜５を形成する。透明導電膜５は通常ＩＴＯをスパッタ等で成膜したものが用いられるが、特にＩＴＯに限定されるものではなく、形成方法も限定されない。

【００３６】工程（ｅ）

必要に応じて配向膜６を先に形成する。配向膜６の形成方法、材質は特に限定されるものではなく、公知のものを用いることができる。また、適宜公知の方法によりラビングを行っても良い。

【００３７】工程（ｆ）

本基板をスペーサー描画機に配置し、カラーフィルタの着色層３を形成するときに用いたアライメントマーク（図示しない）を利用して基板アライメントを行い、インクジェットヘッド８を用い、硬化性インク９を有効画素部に吐出する。

【００３８】この時、本実施形態においては、図３に示すように、硬化性インク９をインクジェットヘッド８により基板上の同一箇所に複数回吐出することにより、スペーサー１０を形成する。これは、１回の吐出だけでは、硬化性インク９が配向膜６上に広がってしまい、スペーサーとして必要とされる高さが得られにくいためである。なお、このように硬化性インク９を同一箇所に複数回吐出する場合、後から吐出する硬化性インクほどその量を少なくしたり、先に吐出した硬化性インクをある程度硬化させた後にその上にさらに硬化性インクを吐出したりすることにより、スペーサーの必要高さがより得られやすくなる。

【００３９】図４は、本実施形態における、スペーサーの目標形状の一例を示す側断面図である。既に図３で示したように、後から吐出する硬化性インクほど量を少なくし、スペーサーを図４に示すような台形形状にすることが、スペーサーの高さをかせぐ点で好ましい。

【００４０】なお、図３の例では、基板上の同一箇所に硬化性インク９を３回吐出してスペーサー１０を形成す

る例を示しているが、本発明は、３回の吐出に限定されるものではなく、必要に応じて２回、あるいは４回以上の吐出でスペーサーを形成してもよい。

【００４１】硬化性インク９は、硬化後にスペーサー１０となるスペーサー形成素材であり、硬化性成分を含有し、インクジェットヘッドを用いて吐出が可能であり、且つ、後処理により硬化し得るものであれば、いずれの材料を用いてもかまわない。好ましくは、以下に挙げるような単量体の単独重合体或いは該単量体と他のビニル系単量体との共重合体をインク中に含有しており、その含有量は０．０１～３０重量％が好ましく、特に０．１～１５重量％が望ましい。

【００４２】硬化性インク９に含有される重合体或いは共重合体の構成成分である単量体としては、例えば、Ｎ，Ｎ－ジメチロールアクリルアミド、Ｎ，Ｎ－ジメトキシメチルアクリルアミド、Ｎ，Ｎ－ジエトキシメチルアクリルアミド、Ｎ，Ｎ－ジメチロールメタクリルアミド、Ｎ，Ｎ－ジメトキシメチルメタクリルアミド、Ｎ，Ｎ－ジエトキシメチルメタクリルアミド等が挙げられるが、これに限られるものではない。これらの単量体は単独重合体、或いは、他のビニル系単量体との共重合体で用いられる。他のビニル系単量体としては、アクリル酸、メタクリル酸、アクリル酸メチル、アクリル酸エチル等のアクリル酸エステル、メタクリル酸メチル、メタクリル酸エチル等のメタクリル酸エステル、ヒドロキシメチルメタクリレート、ヒドロキシエチルメタクリレート、ヒドロキシメチルアクリレート、ヒドロキシエチルアクリレート等の水酸基を含有したビニル系単量体、その他スチレン、α－メチルスチレン、アクリルアミド、メタクリルアミド、アクリロニトリル、アリルアミン、ビニルアミン、酢酸ビニル、プロピオン酸ビニル等を挙げることができる。

【００４３】上記共重合体における、上記単量体と他のビニル系単量体との共重合割合（重量％）は、１００％：０％～５％：９５％が好ましく、特に９０％：１０％～１０％：９０％が望ましい。

【００４４】さらに、光硬化させる場合には、各種光硬化性樹脂、光重合開始剤を加えても良い。また、硬化剤インク中で固着等の問題を起こすものでなければ、他の成分として、様々な市販の樹脂や添加剤を加えても良い。具体的には、アクリル系樹脂やエポキシ系樹脂等が好適に用いられる。

【００４５】硬化性インク９の調製に際しては、上記各成分を水／または公知の溶剤で混合、溶解する。この操作は、それ自体公知のものが利用できる。望ましくは、スペーサー１０を形成する基板表面の材質（本実施形態では配向膜６）によって添加溶剤或いは界面活性剤などの添加剤を加えて吐出された硬化性インク９の形成するドットの径を調整することにより、スペーサーの径の調整が可能である。

【００４６】本発明に用いるインクジェット方式としては、エネルギー発生素子として電気熱変換体を用いたバブルジェットタイプ、或いは圧電素子を用いたピエゾジェットタイプ等が使用可能である。硬化性インクの打込み位置、及び打込み量は任意に設定することができる。

【００４７】工程（ｇ）

光照射、熱処理、或いは光照射と熱処理の両方を行って硬化性インク９を硬化させてスペーサー１０を形成し、本発明のスペーサー付基板を得る。光照射や熱処理の方法は公知の方法による。なお、工程（ｆ）において、先に吐出した硬化性インク９をある程度硬化させた後に後の硬化性インクの吐出を行う場合には、先の硬化性インクの吐出の直後に、光照射、熱処理等の硬化工程が行われる場合もある。

【００４８】特に厳密な平坦性が必要な場合には、スペーサー１０の表面を研磨テープ等を用いて研磨してもかまわない。

【００４９】次いで、事前に配向膜６を形成していなかった場合には、配向膜を形成する。

【００５０】以降、上記のスペーサー付基板と、別途作製した対向基板とをシール材を用いて貼り合わせてセルを作製し、液晶を封入することにより、本発明の液晶素子が得られる。

【００５１】次に、本発明の液晶素子の一例を図２に示す。図２は、図１（ｇ）に示した本実施形態のスペーサー付基板を用いて構成した液晶素子の一例の断面模式図である。図中、１１は対向基板、１２は画素電極、１３は配向膜、１４は液晶である。本液晶素子は、画素毎にＴＦＴ（薄膜トランジスタ）を配置したアクティブマトリクスタイプ（いわゆるＴＦＴ型）の液晶素子の一例である。

【００５２】カラー表示の液晶素子は、一般的にカラーフィルタ側の基板１と対向基板１１を合わせ込み、液晶１４を封入することにより形成される。対向基板１１の内側に、ＴＦＴ（図示しない）と透明な画素電極１２がマトリクス状に形成される。また、透明基板１の内側には、画素電極１２に対向する位置に、Ｒ，Ｇ，Ｂが配列するようにカラーフィルタの着色層３が配置され、その上に透明電極膜５（共通電極）が一面に形成される。ブラックマトリクス２は、通常カラーフィルタ側に形成されるが、ＢＭオンアレイタイプの液晶素子においては対向基板１１側に形成される。さらに、両基板の面内には配向膜６，１３が形成されており、これらをラビング処理することにより液晶分子を一定方向に配列させることができる。これらの基板はスペーサー１０を介して対向配置され、シール材（図示しない）によって貼り合わされ、その間隙に液晶１４が充填される。液晶としては一般的に用いられているＴＮ型液晶や強誘電性液晶等いずれも用いることができる。

【００５３】上記液晶素子は、透過型の場合には両基板

の外側に偏光板を設置し、一般的に蛍光灯と散乱板を組み合わせたバックライトを用い、反射型の場合には透明基板１の外側に偏光板を設置して、それぞれ液晶１４を光の透過率を変化させる光シャッターとして機能させることにより表示を行う。
【００５４】上記実施形態においては、ＴＦＴ型の液晶素子について説明したが、本発明は単純マトリクス型等他の駆動タイプの液晶素子にも好ましく適用される。また、本発明の液晶素子は直視型でも投写型でも好適に用いられる。
【００５５】次に、本実施形態の液晶素子の製造方法の具体例について説明する。
【００５６】（実施例）ガラス基板上に０．１μｍ厚のクロム金属膜をスパッタリングで形成し、フォトレジストを用いてエッチングを行い、格子状のブラックマトリクスを得た、その後、公知のインクジェット方式によるカラーフィルタ形成方法を用いてＲ，Ｇ，Ｂの着色層を作製した。その上にスピンコータを用いてアクリル系樹脂の保護層を形成し、平坦化を行った。さらにその上に透明電極のＩＴＯ膜をスパッタリングで形成した。この基板に、図１（ｆ）に示したように、ブラックマトリクス上に以下の組成の硬化性インクをインクジェットヘッドより吐出した。なお、スペーサー形成後にポリイミドからなる配向膜を形成した。
【００５７】［硬化性インクの組成］

共重合体	１０重量％
水	８０重量％
エチレングリコール	１０重量％

但し、上記共重合体は、Ｎ，Ｎ－ジメチロールアクリルアミドとメタクリル酸メチルの２元共重合体（共重合比、４０：６０（重量比））からなるものを用いた。
【００５８】なお、本実施例では、３回の硬化性インクの吐出によりスペーサーを形成する。この場合、本実施例では、１回目の吐出において２０ｎｇ、２回目で１５ｎｇ、３回目で１０ｎｇの硬化性インクを基板上に吐出した。これにより図４に示したように断面略台形状のスペーサを形成した。
【００５９】上記基板を１００℃で１５分間加熱した後、２００℃で３０分間加熱し、上記硬化性インクを硬化させてスペーサーを形成した。スペーサーは厚さ５μｍで、直径が約２０μｍであった。
【００６０】次いで、上記スペーサーを形成した基板と、対向する電極を形成した基板とをシール材を用いて貼り合わせてセルを作製し、液晶を注入して本発明の液晶素子を得た。得られた液晶素子は、従来の６μｍ径のスペーサーを分散させた液晶素子に比べて色ムラもなく、コントラストに優れたものであった。
【００６１】本発明は、特にインクジェット記録方式の中でも、インク吐出を行わせるために利用されるエネルギーとして熱エネルギーを発生する手段（例えば電気熱変換体やレーザ光等）を備え、前記熱エネルギーによりインクの状態変化を生起させる方式のプリント装置について説明したが、かかる方式によれば記録の高密度化、高精細化が達成できる。
【００６２】その代表的な構成や原理については、例えば、米国特許第４７２３１２９号明細書、同第４７４０７９６号明細書に開示されている基本的な原理を用いて行うものが好ましい。この方式はいわゆるオンデマンド型、コンティニュアス型のいずれにも適用可能であるが、特に、オンデマンド型の場合には、液体（インク）が保持されているシートや液路に対応して配置されている電気熱変換体に、記録情報に対応していて膜沸騰を越える急速な温度上昇を与える少なくとも１つの駆動信号を印加することによって、電気熱変換体に熱エネルギーを発生せしめ、記録ヘッドの熱作用面に膜沸騰を生じさせて、結果的にこの駆動信号に１対１で対応した液体（インク）内の気泡を形成できるので有効である。この気泡の成長、収縮により吐出用開口を介して液体（インク）を吐出させて、少なくとも１つの滴を形成する。この駆動信号をパルス形状をすると、即時適切に気泡の成長収縮が行われるので、特に応答性に優れた液体（インク）の吐出が達成でき、より好ましい。
【００６３】このパルス形状の駆動信号としては、米国特許第４４６３３５９号明細書、同第４３４５２６２号明細書に記載されているようなものが適している。なお、上記熱作用面の温度上昇率に関する発明の米国特許第４３１３１２４号明細書に記載されている条件を採用すると、さらに優れた記録を行うことができる。
【００６４】記録ヘッドの構成としては、上述の各明細書に開示されているような吐出口、液路、電気熱変換体の組み合わせ構成（直線状液流路または直角液流路）の他に熱作用面が屈曲する領域に配置されている構成を開示する米国特許第４５５８３３３号明細書、米国特許第４４５９６００号明細書を用いた構成も本発明に含まれるものである。加えて、複数の電気熱変換体に対して、共通するスロットを電気熱変換体の吐出部とする構成を開示する特開昭５９－１２３６７０号公報や熱エネルギーの圧力波を吸収する開口を吐出部に対応させる構成を開示する特開昭５９－１３８４６１号公報に基づいた構成としても良い。
【００６５】さらに、記録装置が記録できる最大記録媒体の幅に対応した長さを有するフルラインタイプの記録ヘッドとしては、上述した明細書に開示されているような複数記録ヘッドの組み合わせによってその長さを満たす構成や、一体的に形成された１個の記録ヘッドとしての構成のいずれでもよい。
【００６６】加えて、装置本体に装着されることで、装置本体との電気的な接続や装置本体からのインクの供給が可能になる交換自在のチップタイプの記録ヘッド、あるいは記録ヘッド自体に一体的にインクタンクが設けら

れたカートリッジタイプの記録ヘッドを用いてもよい。

【００６７】また、本発明の記録装置の構成として設けられる、記録ヘッドに対しての回復手段、予備的な補助手段等を付加することは本発明の効果を一層安定にできるので好ましいものである。これらを具体的に挙げれば、記録ヘッドに対してのキャッピング手段、クリーニング手段、加圧あるいは吸引手段、電気熱変換体あるいはこれとは別の加熱素子あるいはこれらの組み合わせによる予備加熱手段、記録とは別の吐出を行う予備吐出モードを行うことも安定した記録を行うために有効である。

【００６８】以上説明した本発明実施例においては、インクを液体として説明しているが、室温やそれ以下で固化するインクであっても、室温で軟化もしくは液化するものを用いても良く、使用記録信号付与時にインクが液状をなすものであればよい。

【００６９】加えて、積極的に熱エネルギーによる昇温をインクの固形状態から液体状態への状態変化のエネルギーとして使用せしめることで積極的に防止するため、またはインクの蒸発を防止するため、放置状態で固化し加熱によって液化するインクを用いても良い。いずれにしても熱エネルギーの記録信号に応じた付与によってインクが液化し、液状インクが吐出されるものや、記録媒体に到達する時点では既に固化し始めるもの等のような、熱エネルギーの付与によって初めて液化する性質のインクを使用する場合も本発明は適用可能である。このような場合インクは、特開昭５４－５６８４７号公報あるいは特開昭６０－７１２６０号公報に記載されるような、多孔質シート凹部または貫通孔に液状または固形物として保持された状態で、電気熱変換体に対して対向するような形態としてもよい。本発明においては、上述した各インクに対して最も有効なものは、上述した膜沸騰方式を実行するものである。

【００７０】＊

＊【発明の効果】以上説明したように、本発明によれば、高価なフォトリソグラフィ工程を経ず、任意の場所にスペーサーを形成することができるため、他の構成部材に影響を与えることなく安価にスペーサーを形成することができる。また、非有効画素部にのみスペーサーを形成することができるため、スペーサーの使用による表示への影響が防止される。よって、本発明によれば、従来のスペーサーを分散していた液晶素子に比べて表示品位に優れた液晶素子を、塗工工程及びフォトリソグラフィ工程を用いてスペーサーを形成していた液晶素子よりも安価に提供することが可能となる。

【図面の簡単な説明】

【図１】本発明の液晶素子の製造方法の一実施形態の工程図である。

【図２】本発明の液晶素子の一実施形態の断面模式図である。

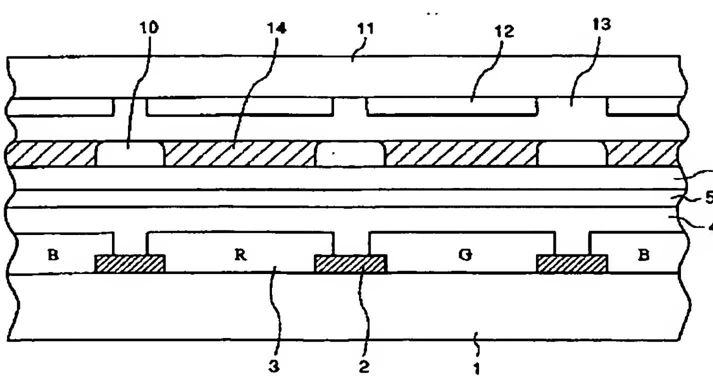
【図３】硬化性インクの複数回の吐出によりスペーサーを形成する様子を示す図である。

【図４】スペーサーの形状目標例を示す図である。

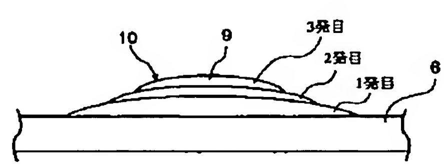
【符号の説明】

1　透明基板
2　ブラックマトリクス
3　着色層
4　保護層
5　透明電極
6　配向膜
8　インクジェットヘッド
9　硬化性インク
１０　スペーサー
１１　対向基板
１２　画素電極
１３　配向膜
１４　液晶

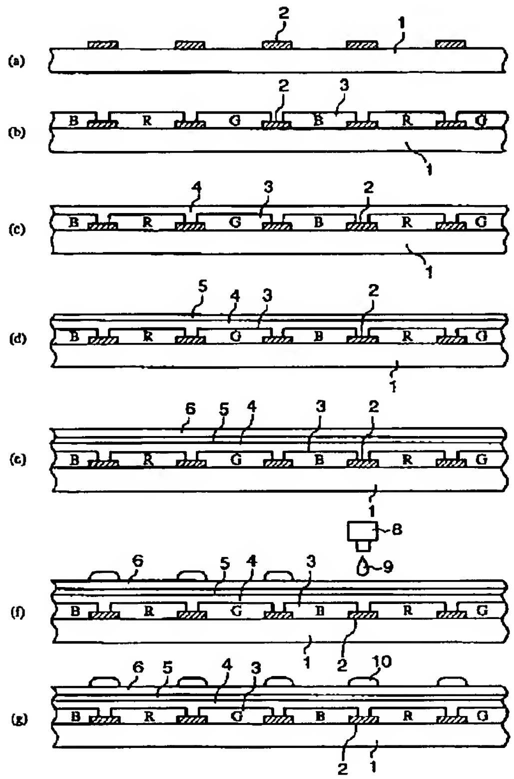
【図２】



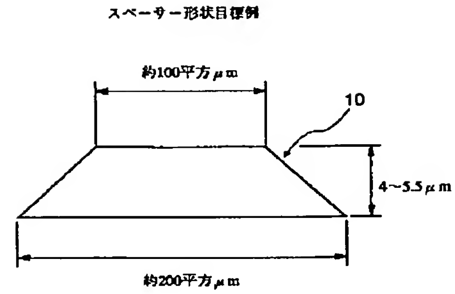
【図３】



【図１】



【図４】



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Hirose et al.

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(45) **Date of Patent:** **Dec. 31, 2002**

(54) **LIQUID CRYSTAL ELEMENTAL DEVICE, PRODUCTION PROCESS THEREOF AND SPACER-BEARING SUBSTRATE**

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Sep. 13, 1999	(JP)	11-259435
Oct. 7, 1999	(JP)	11-286158
Oct. 18, 1999	(JP)	11-295517

(51) **Int. Cl.**⁷ **G02F 1/1339**
(52) **U.S. Cl.** **349/155**
(58) **Field of Search** 349/153, 157; 430/7

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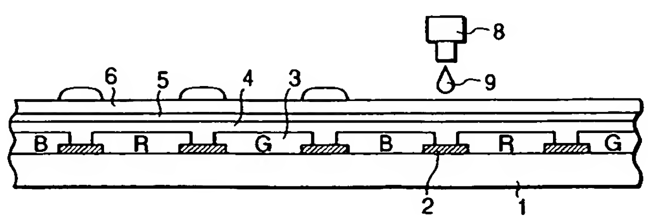
(57) **ABSTRACT**

A liquid crystal elemental device comprising a pair of substrates arranged in opposed relation to each other through a spacer and a liquid crystal held in a space between the substrates is produced by applying a spacer-forming material onto one of the pair of substrates by an ink-jet system to form the spacer, arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and enclosing a liquid crystal compound in the space between the pair of substrates.

3 Claims, 8 Drawing Sheets



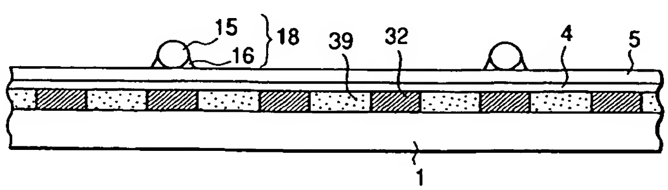


FIG. 1A

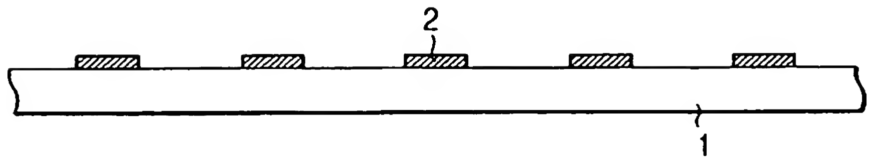


FIG. 1B

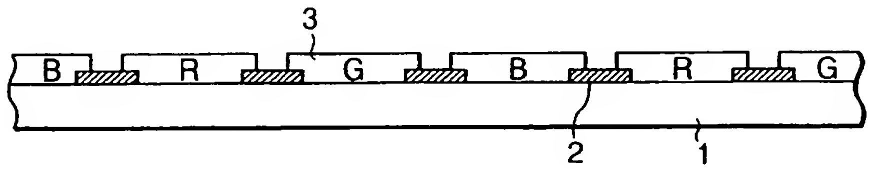


FIG. 1C

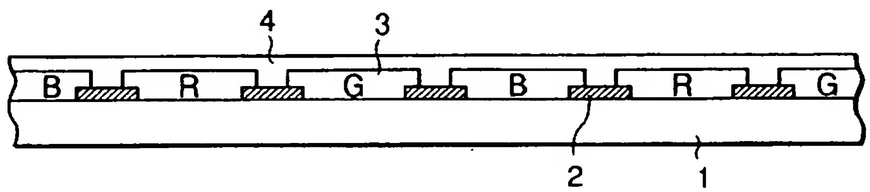


FIG. 1D

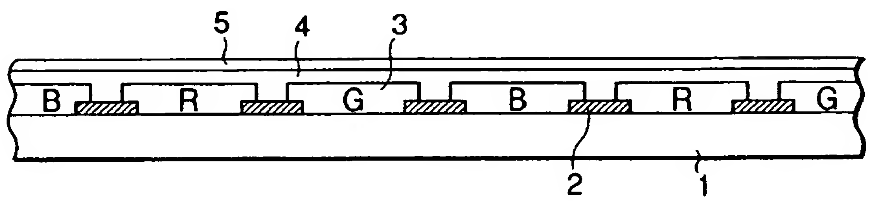


FIG. 1E

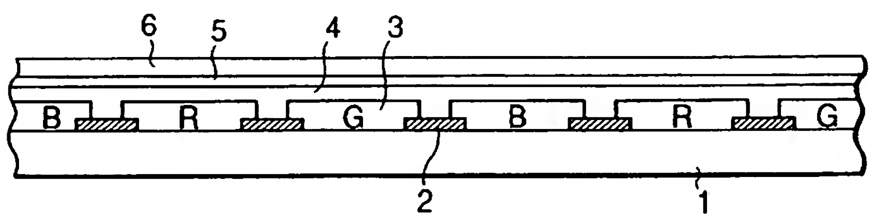


FIG. 1F

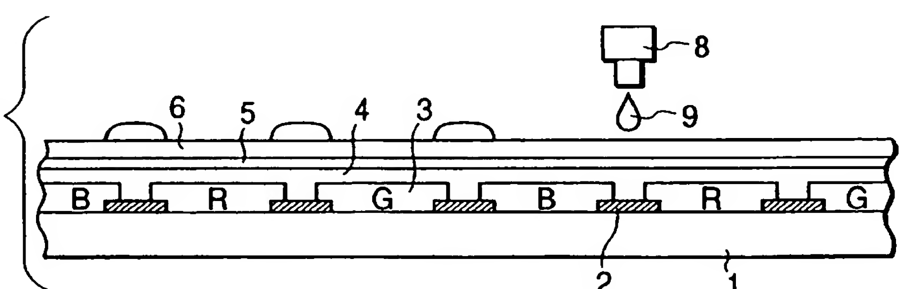


FIG. 1G

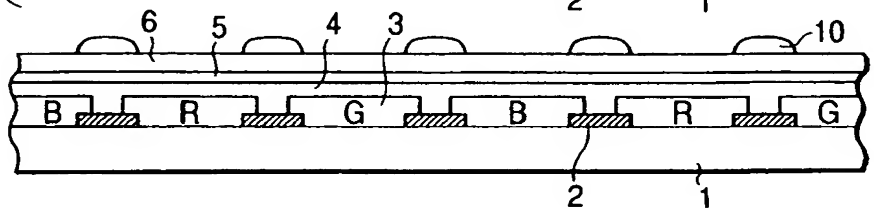


FIG. 2

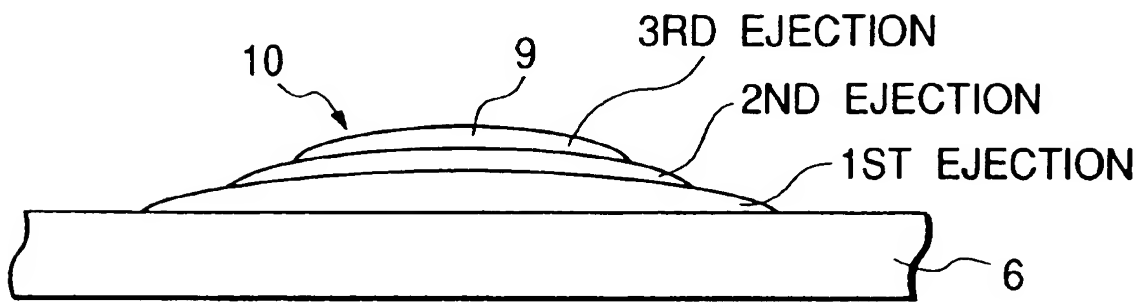

10
9
3RD EJECTION
2ND EJECTION
1ST EJECTION
6

FIG. 3

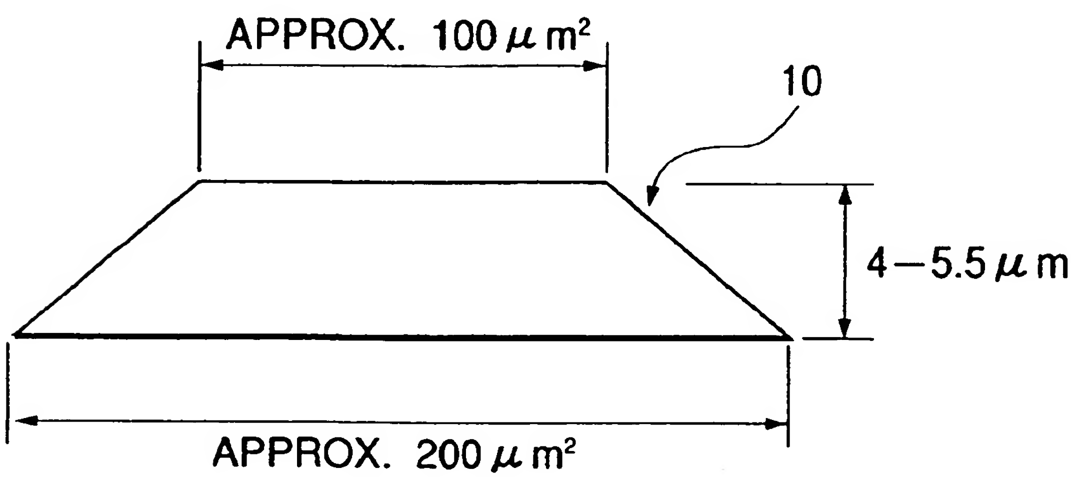

APPROX. 100 μm²
10
4−5.5 μm
APPROX. 200 μm²

FIG. 4

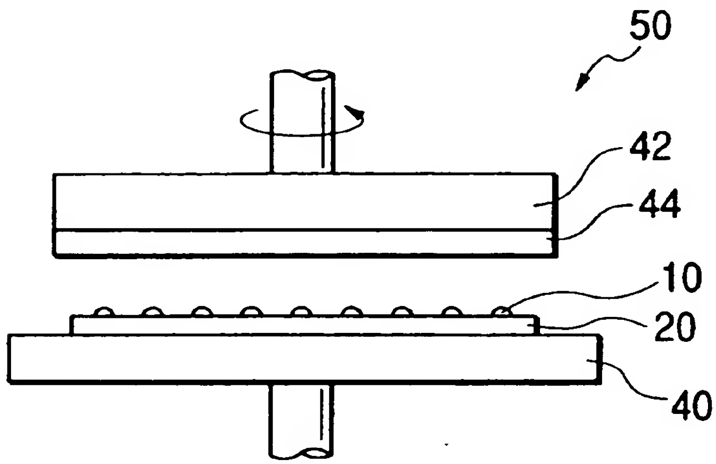


FIG. 5

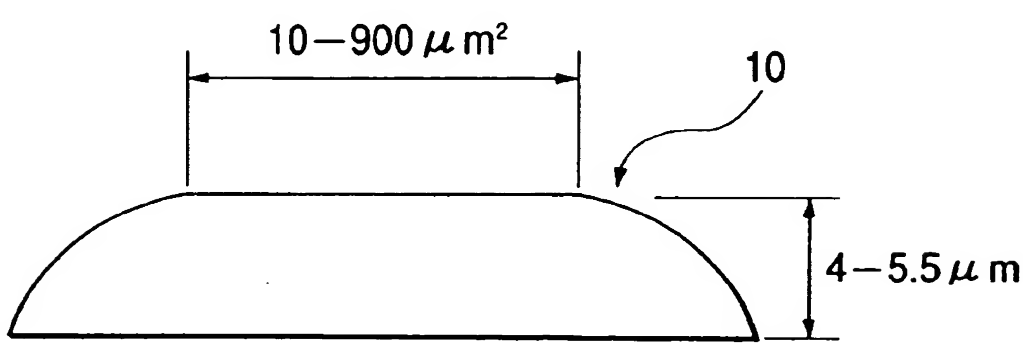


FIG. 6

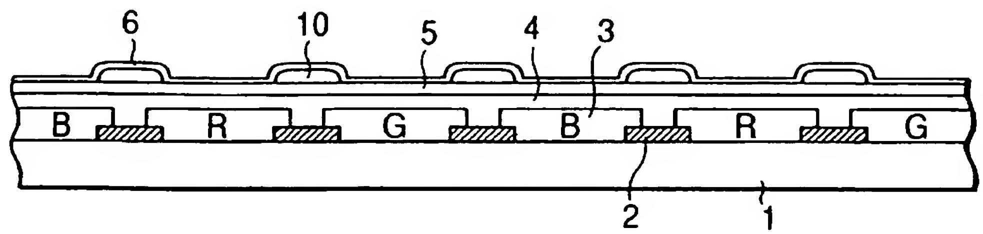


FIG. 7

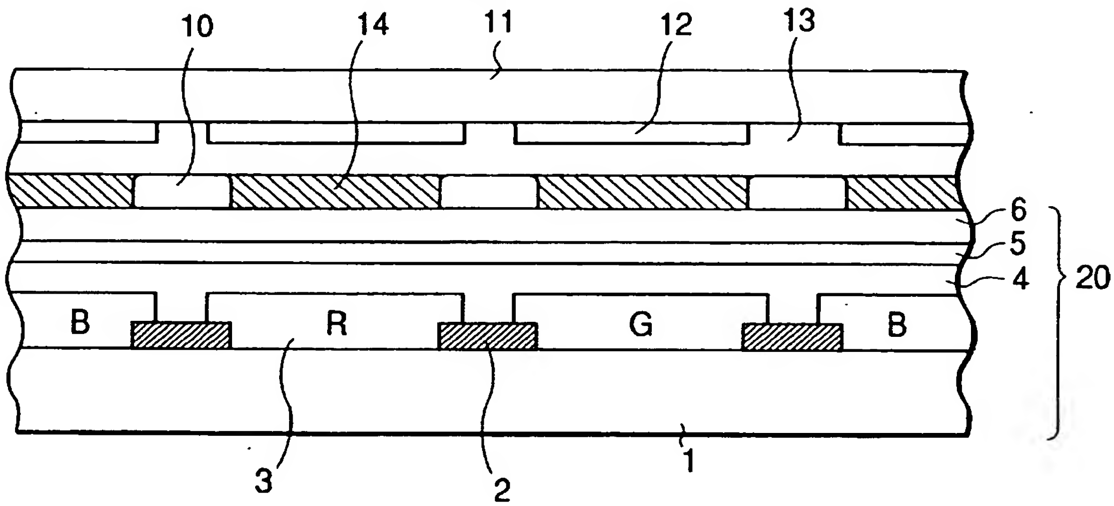


FIG. 8

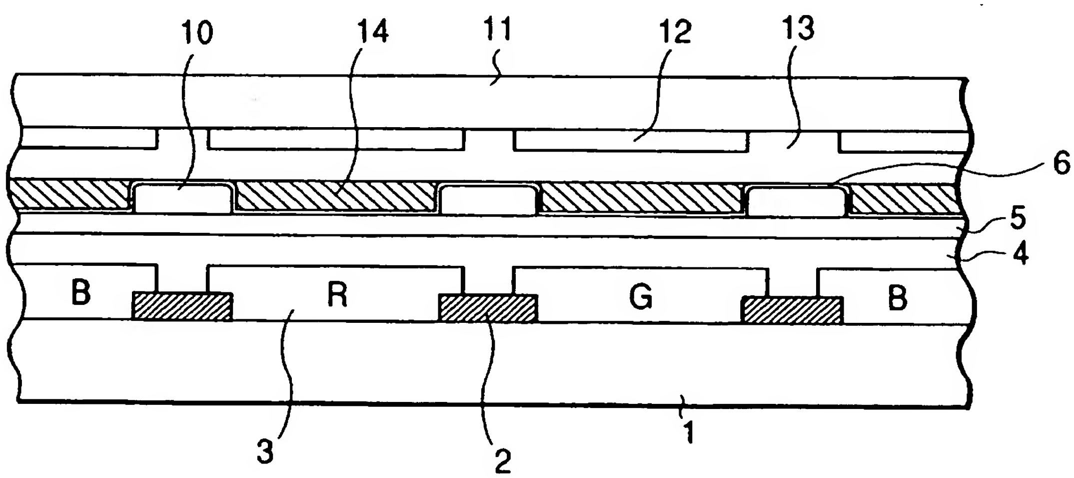


FIG. 9A

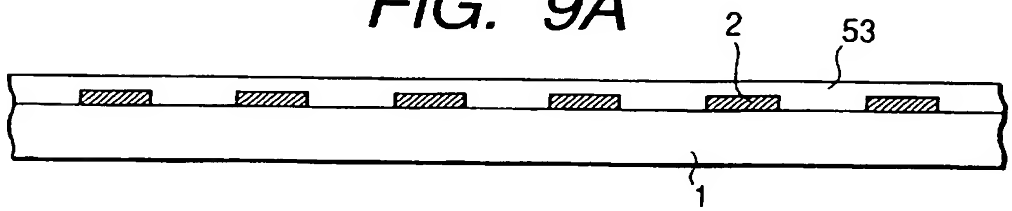


FIG. 9B

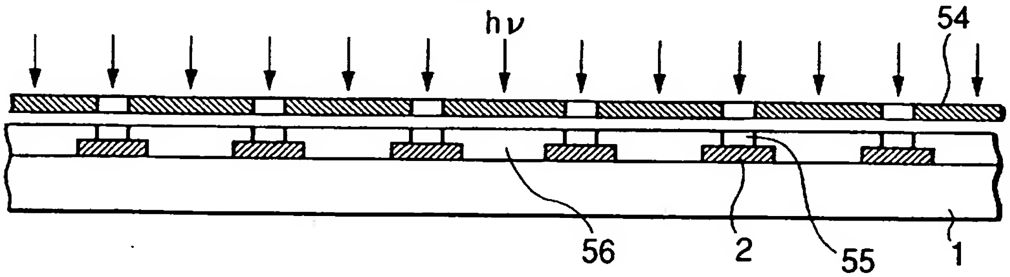


FIG. 9C

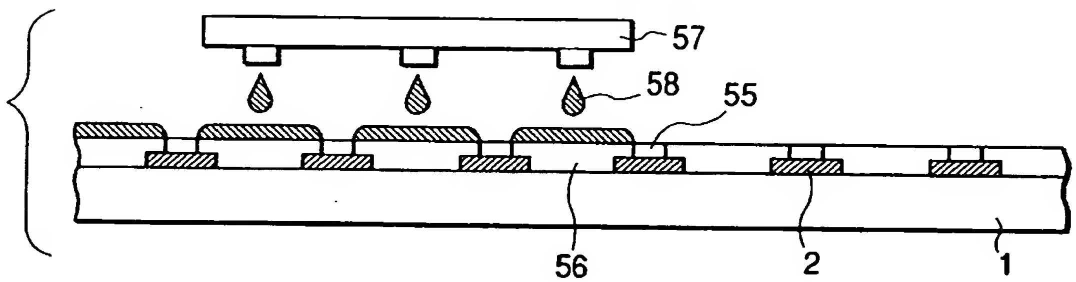


FIG. 9D

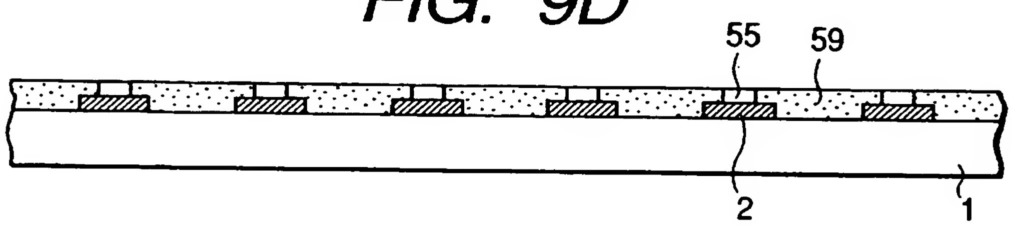


FIG. 9E

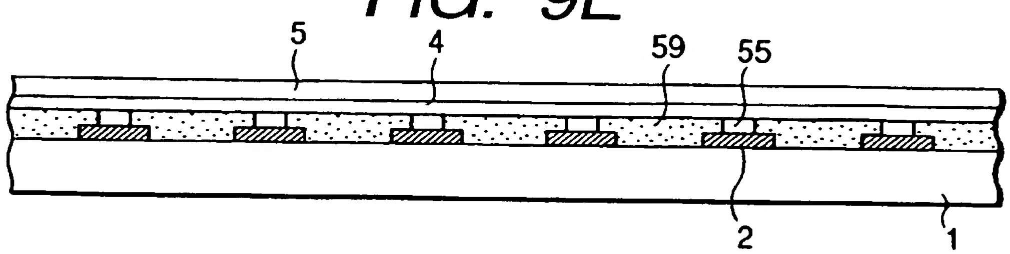


FIG. 9F

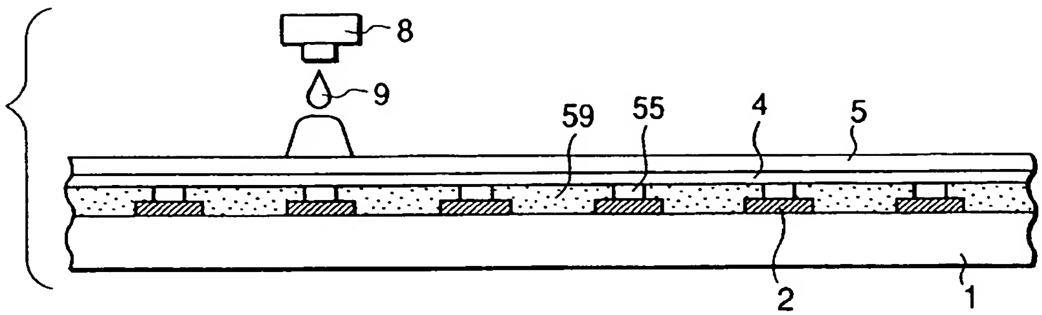


FIG. 9G

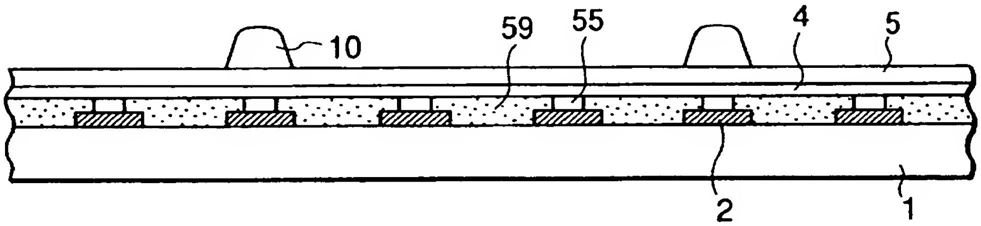


FIG. 10

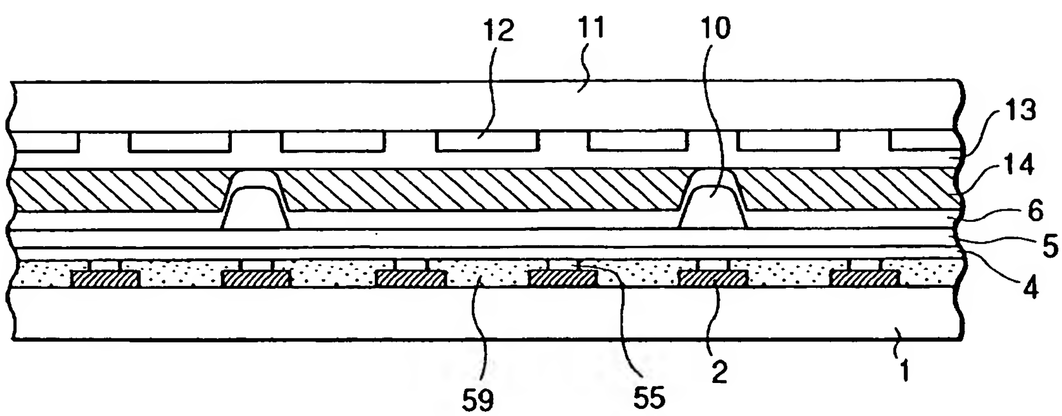


FIG. 11A

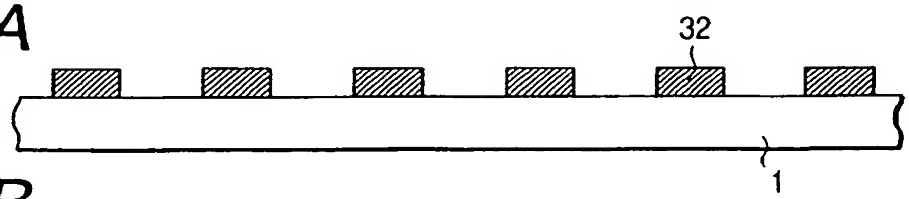


FIG. 11B

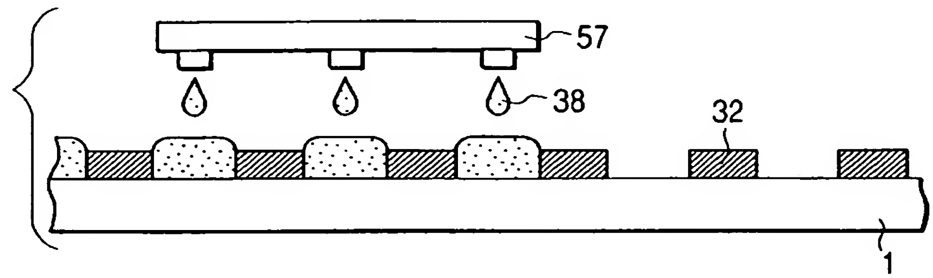


FIG. 11C

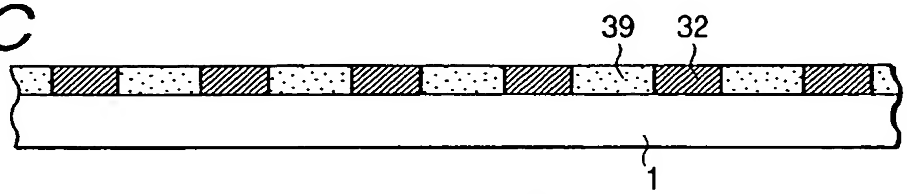


FIG. 11D

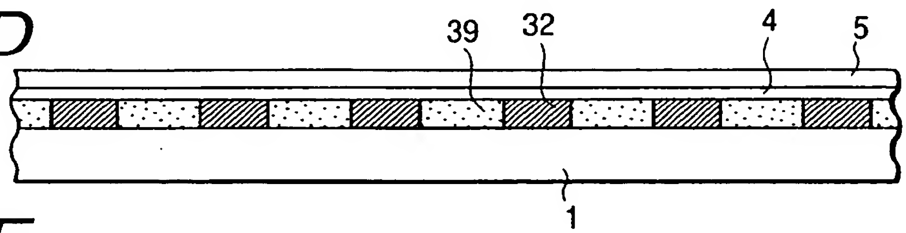


FIG. 11E

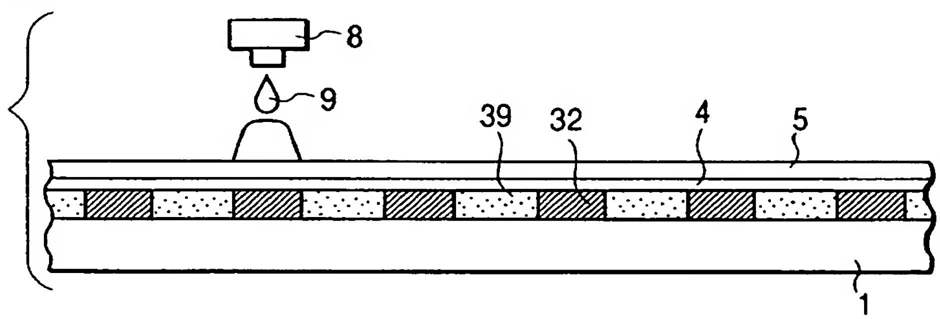


FIG. 11F

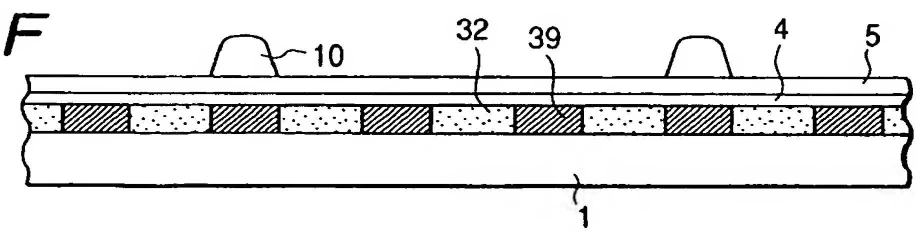
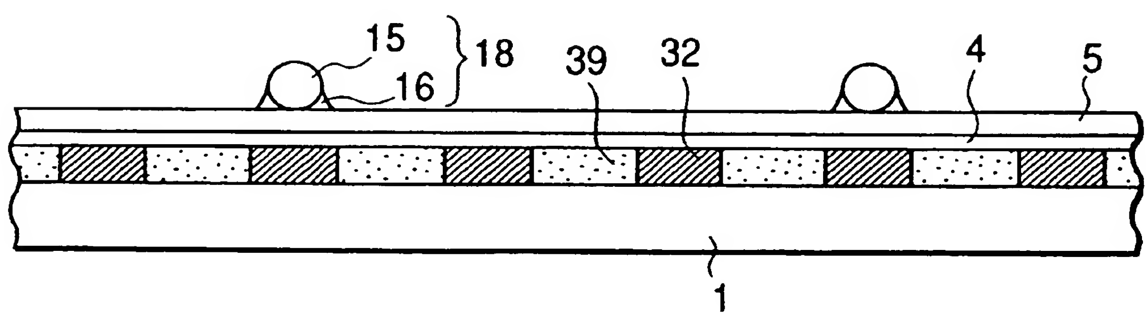


FIG. 12



LIQUID CRYSTAL ELEMENTAL DEVICE, PRODUCTION PROCESS THEREOF AND SPACER-BEARING SUBSTRATE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a liquid crystal elemental device production process. The device is suitable for use in color televisions, personal computers and the like. The invention also relates to a liquid crystal elemental device produced by the production process and a substrate which is a constituent member of the liquid crystal elemental device.

2. Related Background Art

With the advancement of personal computers, particularly, portable personal computers in recent years, the demand for color liquid crystal display devices has been increasing. It is, however, necessary to reduce the manufacturing cost of color liquid crystal display devices in order to make their use more widespread.

In a conventional production process of a liquid crystal elemental device, an elemental device for driving a liquid crystal, such as a TFT (thin film transistor), or an optical elemental device for coloring, such as a color filter, is provided on a pair of glass substrates which are transparent insulating substrates, and both transparent electrode and orientation film are then formed on each of the substrates. Spherical or cylindrical particles composed of silica, alumina, a synthetic resin or the like and having a particle diameter of about 3 to 10 μm are then dispersed as a spacer on the whole surface of one of the glass substrates on which the transparent electrode and orientation film have been formed. The pair of glass substrates are superimposed on each other through the spacer thus formed with the transparent electrodes opposed to each other, and a liquid crystal is enclosed in a space between the substrates, thereby producing a liquid crystal elemental device.

However, since a state of transmission/shading varies in effective pixel portions according to display condition, each spacer is observed as a bright point upon shading when the spacer is formed with a colorless, transparent material, or as a black point upon transmission when the spacer is colored black. This has caused problematic display quality deterioration.

In order to solve the above problem, there has been proposed a process in which an orientation film is subjected to an orientation treatment and then coated with a photosensitive polyimide or photoresist to conduct exposure through a mask, thereby forming spacers composed of the polyimide or photoresist at portions other than effective pixel portions as shown in Japanese Patent Application Laid-Open No. 61-173221, Japanese Patent Application Laid-Open No. 2-223922 or the like. According to this process, the spacer can be formed at arbitrary places with an arbitrary density, so that unevenness of cell gap in the liquid crystal elemental device when a liquid crystal is enclosed can be improved. Japanese Patent Application Laid-Open No. 3-94230 describes a process for fixing a spacer comprising beads on a shading layer in a region other than effective pixel portions.

Besides, there have been proposed methods in which a very thick black matrix is used as a spacer (Japanese Patent Application Laid-Open Nos. 63-237032, 3-184022 and 4-122914), in which an overlapped colored resist is used as a spacer (Japanese Patent Application Laid-Open No. 63-82405), and in which a colored pattern is also formed on

a black matrix to use it as a spacer (Japanese Patent Application Laid-Open No. 63-237032).

All the methods proposed above are methods making use of photolithography and hence have involved problems in that an expensive exposure apparatus is required, and a production line is elongated due to the introduction of a wet process such as development.

In the above improving methods, it is necessary to directly apply the photosensitive polyimide or photoresist on to an orientation film formed of a polyimide film subjected to an orientation treatment by a rubbing process or the like and remove an unnecessary portion thereof with a solvent or the like after exposure. These steps may markedly contaminate or alter the state of orientation of the oriented film in some cases, and so there is a possibility that the orientation of a liquid crystal injected into a liquid crystal cell may be made uneven.

SUMMARY OF THE INVENTION

It is an object of the present invention to solve the above problems and provide a process for producing a liquid crystal elemental device free from the influence of a spacer on both effective pixel portions and non-effective pixel portions from the viewpoint of display and excellent in display quality without an increase in cost.

The above object can be achieved by the present invention described below.

According to the present invention, there is thus provided a process for producing a liquid crystal elemental device comprising a pair of substrates arranged in opposed relation to each other through a spacer and a liquid crystal held in a space between the substrates, which comprises the steps of applying a spacer-forming material onto one of the pair of substrates by an ink-jet system to form the spacer, arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and enclosing a liquid crystal compound in the space between the pair of substrates.

According to the present invention, there is also provided a process for producing a liquid crystal elemental device comprising a pair of substrates arranged in opposed relation to each other through a spacer and a liquid crystal held in a space between the substrates, which comprises the steps of applying a spacer-forming material a plurality of times to be built up onto one of the pair of substrates to form the spacer, arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and enclosing a liquid crystal compound in the space between the pair of substrates.

According to the present invention, there is further provided a process for producing a liquid crystal elemental device comprising a pair of substrates arranged in opposed relation to each other through a spacer and a liquid crystal held in a space between the substrates, which comprises the steps of applying a spacer-forming material onto one of the pair of substrates to form the spacer, flattening the top of the spacer, arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and enclosing a liquid crystal compound in the space between the pair of substrates.

According to the present invention, there is still further provided a process for producing a spacer-bearing substrate, which comprises the steps of forming a colored layer on a substrate, and applying a spacer-forming material by an ink-jet system to form a spacer.

According to the present invention, there is yet still further provided a process for producing a spacer-bearing

substrate, which comprises the step of applying a spacer-forming material a plurality of times to be built up onto a substrate to form a spacer.

According to the present invention, there is yet still further provided a process for producing a spacer-bearing substrate, which comprises the steps of forming a spacer composed of a spacer-forming material on a substrate and flattening the top of the spacer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A, 1B, 1C, 1D, 1E, 1F and 1G are flow charts illustrating a production process of a liquid crystal elemental device according to an embodiment of the present invention.

FIG. 2 illustrates how to form a spacer by ejecting a curable, spacer-forming material plural times.

FIG. 3 illustrates an exemplary target shape of a spacer.

FIG. 4 illustrates the construction of an abrading device for abrading a spacer.

FIG. 5 illustrates another exemplary target shape of a spacer.

FIG. 6 is a schematic cross-sectional view illustrating a spacer-bearing substrate according to an embodiment of the present invention.

FIG. 7 is a schematic cross-sectional view illustrating a liquid crystal elemental device according to an embodiment of the present invention.

FIG. 8 is a schematic cross-sectional view illustrating a liquid crystal elemental device according to another embodiment of the present invention.

FIGS. 9A, 9B, 9C, 9D, 9E, 9F and 9G are flow charts illustrating a production process of a liquid crystal elemental device according to another embodiment of the present invention.

FIG. 10 is a schematic cross-sectional view illustrating a liquid crystal elemental device according to a further embodiment of the present invention.

FIGS. 11A, 11B, 11C, 11D, 11E and 11F are flow charts illustrating a production process of a liquid crystal elemental device according to a further embodiment of the present invention.

FIG. 12 is a schematic cross-sectional view illustrating a spacer-bearing substrate according to another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1A to 1G schematically illustrate steps of the formation of a spacer-bearing substrate in a production process of a liquid crystal elemental device according to an embodiment of the present invention. This embodiment is the case where one substrate is constituted by a color filter with a colored layer and a protective layer provided on a transparent substrate, and a spacer is formed on this substrate. In FIGS. 1A to 1G, reference numeral **1** indicates a transparent substrate, **2** a black matrix, **3** a colored layer, **4** a protective layer, **5** a transparent electrode, **6** an orientation film, **8** an ink-jet head, **9** a curable, spacer-forming material, and **10** a spacer. Incidentally, FIGS. 1A to 1G are schematic cross-sectional views corresponding to the following Steps (a) through (g), respectively.

In the following description, a system in which a spacer-forming material is ejected in place of an ink according to the conventionally known ink-jet system is referred to herein as the ink-jet system for the sake of convenience. The spacer-forming material means a material which will serve as a spacer after curing.

Step (a)

A black matrix **2** is formed on a transparent substrate **1** as needed. For the transparent substrate **1** in the present invention, a glass sheet is generally used. However, the substrate is not limited to the glass substrate so far as it has properties required of a liquid crystal elemental device, such as transparency and mechanical strength, and a plastic substrate may also be used.

No particular limitation is imposed on the black matrix **2**, and any publicly known black matrix may be used. For example, the black matrix can be formed by etching a laminated film of a metal such as Cr or a metal oxide formed on the transparent substrate **1** in a pattern shape or by patterning a black resist coated on the transparent substrate **1**.

Step (b)

A colored layer **3** composed of colored patterns of red (R), green (G) and blue (B) is formed on the transparent substrate. No particular limitation is imposed on a process for forming the colored layer **3** in the present invention, and any publicly known technique may be used. Examples thereof include a pigment dispersing process using photosetting resin compositions in which a pigment has been dispersed, a dyeing process comprising dyeing a resin film formed on a substrate with dyes, an electrodeposition process comprising electrodepositing colored compositions on an electroconductive substrate while energizing the substrate, thereby forming a colored layer, a printing process putting a printing technique into practice, and a thermal transfer process putting a thermal transfer technique into practice. A process making good use of an ink-jet system, by which a colored layer composed of 3 colored patterns can be formed at the same time by a single step, is desirable from the viewpoint of cost.

It is not always necessary to provide the colored layer **3** on a substrate on which a spacer **10** will be formed, and it is only necessary to form it on one of a pair of substrates making up a liquid crystal elemental device.

Step (c)

A protective layer **4** is formed as needed. For the protective layer **4**, a resin layer capable of being cured by light irradiation, heat treatment or a combination thereof or an inorganic film formed by vapor deposition or sputtering may be used. However, any layer or film may be used so far as it has sufficient transparency to be used in a color filter and withstands a subsequent ITO film-forming step, orientated-film-forming step and the like.

Step (d)

A transparent electroconductive film (electrode) **5** is formed as needed. An ITO film formed by sputtering or the like is generally used for the transparent electroconductive film **5**. However, the transparent electroconductive film **5** is not particularly limited to an ITO film, and a forming process thereof is also not limited in any way.

Step (e)

An orientation film **6** is formed in advance as needed. No particular limitation is imposed on the process and material for forming the orientation film **6**, and any publicly known process and material may be used. The orientation film **6** may also be suitably subjected to a rubbing treatment by any publicly known method in advance.

Step (f)

The substrate is set into a spacer-writing machine to conduct substrate alignment utilizing alignment marks (not illustrated) used in the formation of the colored layer **3**,

thereby ejecting a curable, spacer-forming material 9 onto effective pixel portions by means of an ink-jet head.

The curable, spacer-forming material 9 will become a spacer after curing. For such a material, any material may be used so far as it contains a curable component and is capable of being ejected by means of an ink-jet head and being cured by a post treatment. The curable, spacer-forming material 9 preferably contains a homopolymer of one of such monomers as mentioned below or a copolymer of such a monomer with another vinyl monomer, and the content of such a polymer is 0.01 to 30% by weight, more preferably 0.1 to 15% by weight, particularly desirably 0.1 to 10% by weight.

Examples of the monomer which is a component of the polymer or copolymer contained in the curable, spacer-forming material 9 include N,N-dimethylol-acrylamide, N,N-dimethoxymethylacrylamide, N,N-diethoxymethylacrylamide, N,N-dimethylolmethacrylamide, N,N-dimethoxymethylmethacrylamide and N,N-diethoxymethylmethacrylamide. However, the monomers are not limited thereto. These monomers are used in the form of homopolymers or copolymers with other vinyl monomers. Examples of other vinyl monomers include acrylic acid, methacrylic acid, acrylic esters such as methyl acrylate and ethyl acrylate, methacrylic esters such as methyl methacrylate and ethyl methacrylate, hydroxyl group-containing vinyl monomers such as hydroxymethyl methacrylate, hydroxyethyl methacrylate, hydroxymethyl acrylate and hydroxyethyl acrylate, and besides styrene, a-methylstyrene, acrylamide, methacrylamide, acrilonitrile, allyamine, vinylamine, vinyl acetate and vinyl propionate.

The copolymerizing proportion, in terms of % by weight, of the above monomer to another vinyl monomer is preferably from 100%:0% to 5%:95%, particularly desirably from 90%:10% to 10%:90%.

When the curable, spacer-forming material is cured by light, various kinds of photosetting resins and photopolymerization initiators may be added thereto. In addition, various kinds of commercially available resins and additives may be added as other components so far as they do not cause problems such as crusting and the like in the curable, spacer-forming material. Specifically, acrylic resins, epoxy resins and the like are preferably used.

The respective components described above are mixed and dissolved in water and/or a publicly known solvent for the preparation of the curable, spacer-forming material. In this process, those known per se in the art may be used. Desirably, an additive solvent or an additive such as a surfactant is added according to the material (orientation film 6 in this embodiment) of the surface of the substrate, on which the spacer 10 is formed, to control the diameter of a dot formed by the curable, spacer-forming material 9 ejected, whereby the diameter of the spacer 10 can be controlled.

For the ink-jet system used in the present invention, a bubble-jet type making use of an electrothermal converter as an energy-generating element or a piezo-jet type making use of a piezoelectric element may be used. The shot-in quantity of the curable, spacer-forming material 9 may be arbitrarily preset. Although the shot-in position of the curable, spacer-forming material 9 may also be arbitrarily preset, it is preferably shot in at a position overlapping with the black matrix.

A cell gap in a liquid crystal elemental device is generally 2 to 10 μm. In the present invention also, a spacer having a height within this range is preferably formed.

The spacer may be formed only at positions necessary to hold a cell gap upon fabrication of a liquid crystal elemental device with a plurality of spacers dispersed in the form of a dot or line in the substrate. Each spacer is preferably formed in a substantially cylindrical shape.

In Step (f), the curable, spacer-forming material 9 may be ejected once to form the spacer 10. However, the curable, spacer-forming material 9 may be ejected plural times at the same position on the substrate by the ink-jet head 8 to overlap each other and build up as illustrated in FIG. 2, thereby forming the spacer 10. The reason for it is that when the curable, spacer-forming material 9 is ejected only once, the curable, spacer-forming material 9 may spread on the orientation film 6 to fail to achieve the height required as a spacer in some cases. Incidentally, when the curable, spacer-forming material 9 is ejected plural times at the same position as described above, the amount of the curable, spacer-forming material ejected later is lessened, or after the curable, spacer-forming material 9 ejected earlier is cured to some extent, the curable, spacer-forming material 9 is further ejected thereon, whereby the height necessary for the spacer is achieved with greater ease.

FIG. 3 is a sectional side elevation illustrating an exemplary target shape of a spacer. It is preferred from the viewpoint of achieving the height necessary for the spacer that the amount of the curable, spacer-forming material ejected later be lessened as illustrated in FIG. 2 to form the spacer into such a trapezoid as illustrated in FIG. 3.

Incidentally, the embodiment illustrated in FIG. 2 shows a case where the curable, spacer-forming material 9 is ejected 3 times at the same position on the substrate to form the spacer 10. However, the present invention is not limited to the three-fold ejection, but the spacer may be formed by two-fold ejection, four-fold ejection or more.

Step (g)

The curable, spacer-forming material 9 is cured by light irradiation, heat treatment or both light irradiation and heat treatment to form the spacer 10, thereby obtaining a spacer-bearing substrate according to the present invention. The light irradiation and heat treatment are conducted in accordance with the respective methods known per se in the art.

When the spacer requires specially strict evenness, the surface of the spacer 10 may be abraded and flattened according to the following Step (h). In this case, shavings remained after the abrasion are preferably cleaned off in the following Step (i).

Step (h)

If the top portion of the spacer 10 formed by the ink-jet system is round, an opposed substrate 11 (see FIG. 7) comes into point contact with the top of the spacer 10 when the opposed substrate 10 is bonded under pressure to the spacer-bearing substrate 20 through the spacer 10, so that it is difficult to control a gap length between both substrates. In addition, since the pressure is applied topically, the spacer 10 is easy to deform, thereby causing thickness irregularity of the gap between both substrates. Therefore, the top of the spacer 10 is necessary to be abraded in Step (h) to flatten it. When the top of the spacer 10 is flattened, the pressure is applied uniformly, so that the gap between both substrates can be controlled with high accuracy, thereby producing a liquid crystal display device which rarely causes display irregularity. Further, even when the shot-in quantity of the spacer-forming material for forming the spacer 10 varies, the height of the spacer 10 can be controlled precisely, and a yield can be enhanced.

In order to flatten the top of the spacer 10, methods such as cutting, hot pressing, tape abrading and buffing are considered, and buffing is most suitable. Incidentally, buffing refers to a method in which an abrasive is provided on the

surface of an abrading base material, and a part to be abraded is brought into contact with the surface of the base material while rotating the abrading base material on its axis, thereby abrading the surface of the part.

FIG. 4 illustrates the construction of an abrading device used for flattening the top of the spacer **10** by buffing.

The abrading device **10** is equipped with a lower holding part **40** that holds the spacer-bearing substrate **20** by suction and an upper holding part **42** opposed to the lower holding part **40**. To the lower surface of the upper holding part **42** is attached an abrading member **44** with a finely particulate abrasive penetrated into an abrading base material. The upper holding part **42** is rotated on its axis in such a state that the abrading member **44** contacts the top of the spacer **10**, whereby the top of the spacer **10** is flatly abraded. The lower holding part **40** is not rotatably driven, but is rotated with the rotation of the upper holding part **42**.

As the abrading base material used in the abrading member **44**, a nonwoven fabric, suede, porous body or the like is preferred. In this embodiment, the nonwoven fabric is used.

An inorganic oxide or the like is used as the abrasive, and an abrasive comprising alumina as a main component is preferred. The particle diameter thereof is preferably about 0.2 μm to 0.3 μm.

FIG. 5 illustrates another exemplary target shape of a spacer **10**. As illustrated in FIG. 5, the top of the spacer **10** is preferably abraded into a flat surface having an average area of 10 to 900 μm^2, preferably 50 to 500 μm^2, more preferably 70 to 300 μm^2. If the surface area is smaller than 10 μm^2, the spacer **10** becomes easy to collapse, so that irregularity may occur in the gap between both substrates in some cases. If the surface area is greater than 900 μm^2, such a spacer may project from a shading region in some cases. The height of the spacer **10** varies according to a liquid crystal material used. However, in the case of a TN liquid crystal, the top of the spacer **10** is preferably abraded so as to give a height of 4 to 5.5 μm. The above numerical values can be inspected through an optical microscope.

Step (i)

The spacer-bearing substrate **20**, the spacer **10** of which has been abraded in Step (h), is subjected to ultrasonic cleaning for removing shavings by the abrasion, and the like. The ultrasonic cleaning is conducted by, for example, immersing the spacer-bearing substrate **20** in an ultrasonic cleaning bath and applying a 100 kHz ultrasonic wave of 250 W for 1 minute.

The orientation film **6** is not always required to be provided before the formation of the spacer **10**, but may be provided after the formation of the spacer **10** as illustrated in FIG. **6**.

The present invention is practiced by an ink-jet system making use of thermal energy as energy utilized for ejecting the spacer-forming material, whereby high density and high definition formation of the spacer can be achieved.

The typical construction and principle thereof preferably follow the basic principle disclosed in, for example, U.S. Pat. Nos. 4,723,129 and 4,740,796. This system may be applied to either the so-called on-demand type or continuous type. However, the on-demand type is particularly effective because at least one driving signal that responds to recording information and gives a rapid temperature rise beyond film boiling is applied to an electrothermal converter arranged in opposed relation to a sheet or liquid path in which a liquid (ink) is held, whereby thermal energy is generated by the electrothermal converter, thereby causing film boiling on a heat acting surface of a recording head, and consequently a bubble can be formed in the liquid (ink) in relation of 1:1 in response to the driving signal. The liquid (ink) is ejected through an opening for ejection by growth and shrinkage of the bubble to form at least one droplet. It is more preferred that the driving signal be applied in the form of a pulse, since the growth and shrinkage of the bubble are suitably conducted without delay, whereby the liquid (ink) can be ejected with excellent responsiveness in particular.

For the driving signal in the form of a pulse, those described in U.S. Pat. Nos. 4,463,359 and 4,345,262 are suitable. Incidentally, when the conditions described in U.S. Pat. No. 4,313,124 the invention of which relates to the rate of temperature rise on the heat acting surface, are adopted, excellent recording can be conducted.

For the construction of the recording head, besides such construction composed of a combination of an ejection orifice, a liquid path and an electrothermal converter as disclosed in the above-described respective U.S. patents (linear liquid path or right-angle liquid path), the construction disclosed in U.S. Pat. Nos. 4,558,333 and 4,459,600 that a heat acting surface is arranged in a curved region is also embraced in the present invention. In addition, the construction based on Japanese Patent Application Laid-Open No. 59-123670, disclosing the construction that a slot common to a plurality of electrothermal converters is used as an ejection part of the electrothermal converters, or Japanese Patent Application Laid-Open No. 59-138461, disclosing the construction that an opening absorbing the pressure wave of thermal energy is arranged in opposed relation to an ejection part may also be used.

Further, a full-line type recording head having a length corresponding to the width of the greatest recording medium on which recording can be conducted by a recording apparatus may be either the construction that the length is fulfilled by such a combination of plural recording heads as disclosed in the above-described U.S. patents or the construction as one recording head formed integrally.

Thereafter, the above-described spacer-bearing substrate and an opposed substrate fabricated separately are laminated with a sealant to fabricate a cell, and a liquid crystal is enclosed in the cell, thereby obtaining the liquid crystal elemental device according to the present invention.

Examples of the liquid crystal elemental device according to the present invention are illustrated in FIGS. **7** and **8**. FIG. **7** is a schematic cross-sectional view illustrating an exemplary liquid crystal elemental device fabricated using the spacer-bearing substrate according to the present invention illustrated in FIG. 1G. FIG. **8** is a schematic cross-sectional view illustrating an exemplary liquid crystal elemental device fabricated using the spacer-bearing substrate according to the present invention illustrated in FIG. **6**. In FIGS. **7** and **8**, reference numeral **11** indicates an opposed substrate, **12** pixel electrodes, **13** an orientation film, and **14** a liquid crystal. These liquid crystal elemental devices are examples of an active matrix type (so-called TFT type) liquid crystal elemental device in which a TFT (thin film transistor) is arranged for every pixel.

Liquid crystal elemental devices for colored display are generally formed by uniting the substrate **1** on the side of the color filter and the opposed substrate **11** and enclosing the liquid crystal **14** in a space between both substrates. On the inside of the opposed substrate **11**, TFTs (not illustrated) and the transparent pixel electrodes **12** are formed in the form of a matrix. On the inside of the transparent substrate **1**, the colored layer **3** of the color filter is provided in such a manner that colored portions of R, G and B are arranged at positions opposite to the pixel electrodes **12**. The transparent

electroconductive film (common electrode) 6 is formed onto the whole surface of the colored layer. The black matrix 2 is generally formed on the side of the color filter, but formed on the side of the opposed substrate 11 in a liquid crystal elemental device of the BM on array type. The orientation films 6 and 13 are further formed on the respective insides of both substrates. Liquid crystal molecules can be aligned or oriented in a fixed direction by subjecting these films to a rubbing treatment. These substrates are arranged in opposed relation to each other through the spacer 10 and laminated with a sealant (not illustrated). The liquid crystal 14 is filled in a space between both substrates. For the liquid crystal, any of a commonly used TN type liquid crystal, ferroelectric liquid crystal, etc. may be used.

In the case where the liquid crystal elemental device is of a transmission type, polarizing plates are arranged on the outsides of both substrates, and a back light generally composed of a combination of a fluorescent lamp and a scattering plate is used, or in the case where the liquid crystal elemental device is of a reflection type, a polarizing plate is arranged on the outside of the transparent substrate 1. In each case, the liquid crystal 14 functions as an optical shutter for changing the transmittance of light, thereby conducting display.

Although the TFT type liquid crystal elemental devices have been described in the above embodiments. However, the present invention is also preferably applied to liquid crystal elemental devices of other drive types such as the simple matrix type. The liquid crystal elemental devices according to the present invention are suitably used in both direct viewing type and projection type.

A spacer-forming material according to another embodiment will hereinafter be described.

A bead-containing spacer-forming material in which beads are dispersed in an adhesive may be used as the spacer-forming material.

The bead-containing spacer-forming material according to the present invention is formed in the spacer 10 by applying it onto the color filter and then curing the adhesive to fix the beads to the color filter.

For the bead-containing spacer-forming material according to the present invention, a ratio of the specific gravity of the beads to the specific gravity of the adhesive is 0.9 to 1.1, desirably 0.95 to 1.05 from the viewpoint of preventing the precipitation or flotation of the beads in the spacer-forming material.

For the beads contained in the bead-containing spacer-forming material according to the present invention, those having a particle diameter of 0.8 to 10 μm are preferably used from the viewpoint of holding a cell gap in the resulting liquid crystal elemental device, and they are contained in a proportion of preferably 0.1 to 50% by weight, more preferably 1 to 30% by weight in the spacer-forming material. Further, the viscosity of the adhesive is adjusted to preferably 2 to 100 cp, more preferably 3 to 50 cp at 25° C. from the viewpoint of successfully ejecting the spacer-forming material.

Preferably used as the beads used in the bead-containing spacer-forming material according to the present invention are porous bodies, nonporous bodies and hollow bodies of inorganic compounds such as glass, silica and metal oxides (MgO, Al_2O_3, etc.), and plastics such as polystyrene, polyethylene, polypropylene, polyesters, polyacrylics, nylons and silicone resins. In particular, beads of a porous material may be suitably selected, thereby conducting the adjustment of the specific gravity.

The adhesives used in the bead-containing spacer-forming material according to the present invention is cured after the bead-containing spacer-forming material is applied onto the color filter, so as to fix the beads, and a resin composition capable of curing by light irradiation, heat treatment or a combination thereof is preferably used. Specifically, the curable, spacer-forming material described above may be used.

For the ink-jet system used in the application of the bead-containing spacer-forming material, a piezo-jet type making use of a piezoelectric element, or the like may be preferably used. The shot-in position and shot-in quantity of the bead-containing spacer-forming material may be arbitrarily preset.

For the spacer-forming material 9, a material that contains a polymer, copolymer or monomer component as a component curable by light irradiation or heat treatment and that is prepared at a high concentration in which the content of a solvent component is not higher than 50% by weight may be used. The solvent component contained in the spacer-forming material 9 is lessened to prepare a high concentration material as described above, whereby the sufficient height of a droplet required for the spacer can be achieved upon application of the spacer-forming material onto the color filter by an inkjet head, and so a spacer having a sufficient height can be formed in a narrow area. Accordingly, a spacer having a desired height can be selectively formed only over a black matrix 2 having a narrow width with ease.

The content of the solvent component is preferably not higher than 30% by weight, more preferably not higher than 20% by weight, and is not lower than 5% by weight.

A specific component contained in the spacer-forming material 9 includes an acrylic resin, epoxy resin or the like. However, a component by which the viscosity of the spacer-forming material does not become very high is preferred taking its ejectability by the ink-jet system into consideration, and so a monomer or oligomer material curable by light irradiation or heat treatment is preferred. Specifically, monomers or oligomers having at least two ethylenically unsaturated bonds, monomers or oligomers having at least two glycidyl groups, and the like are included. However, such components are not limited thereto.

When the spacer-forming material is cured by light, various kinds of photosetting resins and photopolymerization initiators may be added thereto. In addition, various kinds of commercially available resins and additives may be added as other components so far as they do not cause problems such as crusting and the like in the spacer-forming material.

The respective components described above are mixed and dissolved in water and/or a publicly known solvent when preparing the spacer-forming material 9. In this process, those known per se in the art may be used. Desirably, an additive solvent or an additive such as a surfactant is added according to the material of the surface, on which the spacer 10 is formed, to control the diameter of a dot formed by the spacer-forming material 9 ejected, whereby the diameter of the spacer 10 can be controlled.

A preferable embodiment of a production process of a spacer-bearing color filter, in which a colored layer of the color filter is formed by an ink-jet system, will hereinafter be described with reference to FIGS. 9A to 9G.

Incidentally, FIGS. 9A to 9G correspond to the following Steps (a) to (g), respectively.

Step (a)

A black matrix 2 is formed as a shading layer having apertures on a transparent substrate 1, and an ink-receiving layer 53 composed of a resin composition is formed on the whole surface thereof

The ink-receiving layer **53** is composed of a resin composition curable by light irradiation, heat treatment, or both light irradiation and heat treatment and has ink absorbency. Particularly preferably, the ink-receiving layer **53** is formed by a photosensitive resin composition, the ink absorbency of which is increased or decreased by light irradiation, to form non-coloring portions **55** between adjacent coloring portions **56** by patterning exposure which will be described subsequently, thereby preventing color mixing. For such a photosensitive resin composition, an acrylic resin, epoxy resin, amide resin, phenol resin, polystyrene resin or the like is used in combination wit h a photo-initiator (crosslinking agent) as needed. This embodiment is a case where a negative type photosensitive resin composition, the ink absorbency of which is lowered by light irradiation, is used.

The photosensitive resin composition is applied onto the transparent substrate **1** by a publicly known means such as spin coating, dip coating, roll coating, bar coating or slit coating and prebaked as needed, thereby forming the ink-receiving layer **53**.

Incidentally, the ink-receiving layer **53** is preferably such that the ink absorbency is increased or decreased by light irradiation, and at the same time the wettability by ink is also increased or decreased.

Step (b)

Patterning exposure is conducted through a photomask **54** to form the coloring portions **56** having high ink absorbency and non-coloring portions **55**, the ink absorbency of which is lower (or lost) than that of the coloring portions **56**. In this embodiment, the photosensitivity of the ink-receiving layer **53** is negative, and in this case, a photomask having such an opening pattern that the width of each of the non-coloring portions **55** becomes narrower than the width of the black matrix **2** is preferably used from the viewpoint of forming colored portions **59** wider than the aperture of the black matrix **2** to prevent color skip at aperture portions of the black matrix **2**.

In the case where the photosensitivity of the ink-receiving layer **53** is positive, the black matrix **2** is used as a photomask to conduct exposure from the back side of the transparent substrate **1**, whereby the patterning exposure can be conducted without using any photomask.

Step (c)

Color inks **58** of R (red), G (green) and B (blue) colors are applied to the coloring portions **56** of the ink-receiving layer according to the prescribed coloring pattern by means of an ink-jet head **57**. In this embodiment, the non-coloring portions **55** low (or lost) in ink absorbency are interposed between adjacent coloring portions **56**, so that the respective inks overflowed from the coloring portions **56** are repelled by the non-coloring portions **55**, thereby preventing color mixing between the adjacent coloring portions **56**.

For the color inks used in the present invention, both dye inks and pigment inks may be used, and any inks may be used so far as they can be ejected by an ink-jet system.

For the ink-jet system used in the present invention, a bubble-jet type using an electrothermal converter as an energy-generating element, a piezo-jet type making use of a piezoelectric element, or the like may be used. A coloring area and a coloring pattern may be arbitrarily preset.

Step (d)

After the color inks **58** are absorbed in the respective coloring portions **56** and sufficiently diffused, the ink-receiving layer is subjected to a drying treatment as needed, and the whole surface of the ink-receiving layer is subjected to a necessary treatment such as light irradiation and/or heat treatment to cure the whole ink-receiving layer to form a colored layer composed of the non-coloring portions **55** and the colored portions **59**.

Step (e)

After a protective layer **4** is formed as needed, a transparent electroconductive film **5** which will become an electrode for driving a liquid crystal is formed.

For the transparent electroconductive film **5**, ITO (indium-tin-oxide) film is generally used. Such a film can be formed by sputtering or the like.

Step (f)

A spacer-forming material **9** is partially applied in, preferably, a region overlapping with the black matrix **2** by an ink-jet head **8**.

Step (g)

The spacer-forming material **9** is subjected to a necessary treatment such as light irradiation, heat treatment or both light irradiation and heat treatment to cure the spacer-forming material **9**, thereby forming the spacer **10** to obtain a spacer-bearing color filter according to the present invention. The light irradiation and heat treatment are conducted in accordance with the respective methods known per se in the art.

FIGS. **11A** to **11F** illustrate steps of a production process of a spacer-bearing color filter according to another embodiment of the present invention. In FIGS. **11A** to **11F**, like reference numerals are given to the same members as in FIGS. **9A** to **9G**, and their descriptions are omitted. In FIGS. **11A** to **11F**, reference numeral **32** indicates a black matrix, **57** an ink-jet head, **38** curable color inks, and **39** colored portions. Incidentally, FIGS. **11A** to **11F** correspond to the following Steps (a) to (f), respectively.

Step (a)

A black matrix **32** having apertures is formed with a black resin composition on a transparent substrate **1**. The black matrix **32** has a function as a partition wall for preventing color mixing between curable color inks **38** used for forming colored portions **39**.

For such a black resin composition, a composition having photosensitivity is preferred. Specifically, an acrylic resin, epoxy resin, amide resin, phenol resin, polystyrene resin or the like is used in combination with a photo-initiator (crosslinking agent) as needed, and a black dye or pigment is mixed therewith before use.

After the photosensitive black resin composition is applied on to the transparent substrate **1** by a publicly known means such as spin coating, dip coating, roll coating, bar coating or slit coating and prebaked as needed, patterning exposure and development are conducted to obtain the black matrix **32** having prescribed pattern.

Step (b)

Curable color inks **38** are applied to the apertures of the black matrix **32**. For the curable color inks **38**, colored resin compositions comprising a resin curable by application of energy, such as light irradiation or heat treatment, and a dye or pigment of R, G or B color are used. A melamine resin; a hydroxyl group- or carboxyl group-containing polymer and melamine; a hydroxyl group- or carboxyl group-containing polymer and a polyfunctional epoxy compound; a hydroxyl group- or carboxyl group-containing polymer and a reactive cellulose compound; an epoxy resin and a resol resin; an epoxy resin and an amine; an epoxy resin and a carboxylic acid or an acid anhydride; an epoxy compounds; or a negative resist may be used for the resin.

For the ink-jet system, a bubble-jet type using an electrothermal converter as an energy-generating element, a piezo-jet type making use of a piezoelectric element, or the like may be used as in the application of the color inks in the above embodiment. A coloring pattern may be arbitrarily preset.

Step (c)

The inks applied are subjected to a drying treatment as needed, and then a necessary treatment such as light irradiation and/or heat treatment to cure the curable color inks **38**, thereby forming colored portions **39**. In this embodiment, the colored portions **39** correspond to the colored layer of the color filter.

Step (d)

After a protective layer **4** is formed as needed as in FIG. **9E**, a transparent electroconductive film **5** is formed.

Step (e)

As with FIG. **9F**, a spacer-forming material **9** is partially applied in, preferably, a region overlapping with the black matrix **2** by an ink-jet head **8**.

Step (f)

The spacer-forming material **9** is subjected to a necessary treatment in the same manner as in FIG. **9G** to cure the spacer-forming material **9**, thereby forming the spacer **10** to obtain a spacer-bearing color filter according to the present invention.

FIG. **12** schematically illustrates an exemplary spacer-bearing color filter in which a spacer **18** has been formed with a bead-containing spacer-forming material. According to this spacer **18**, beads **15** are fixed to a transparent electroconductive film **5** with an adhesive **16**.

FIG. **10** is a schematic cross-sectional view illustrating an exemplary liquid crystal elemental device using the spacer-bearing color filter according to the present invention.

A spacer-forming material of a positive or negative type photosensitive resin composition is applied onto the color filter, and then the spacer-forming material which has spread too much is then subjected to patterning exposure and developed, whereby an unnecessary portion of the spacer may be removed. According to this process, a spacer having a proper size can be formed.

The present invention will hereinafter be described more specifically by the following EXAMPLEs.

EXAMPLE 1

A metal chromium film having a thickness of 0.1 μm was formed on a glass substrate by sputtering and etched using a photoresist, thereby obtaining a lattice black matrix. Thereafter, a colored layer composed of colored patterns of R, G and B was formed using a publicly known process for forming a color filter by an ink-jet system. A protective layer composed of an acrylic resin was formed thereon by means of a spin coater to conduct smoothing. An ITO film as a transparent electrode was further formed thereon by sputtering, and an orientation film composed of polyimide was further formed thereon. A curable, spacer-forming material having the following composition was ejected onto the black matrix of this substrate by an ink-jet head as illustrated in FIG. 1F.

Composition of curable, spacer-forming material:

Copolymer	10% by weight
Water	80% by weight
Ethylene glycol	10% by weight

The copolymer used in the above composition was a bipolymer of N,N-dimethylolacrylamide and methyl methacrylate (copolymerization ratio=40:60 by weight).

The above-prepared substrate was heated at 100° C. for 15 minutes and then at 200° C. for 30 minutes to cure the curable, spacer-forming material, thereby forming a spacer.

The substrate on which the spacer had been formed and a substrate on which opposed electrodes had been formed were laminated with a sealant to fabricate a cell. A liquid crystal was filled into the cell to obtain a liquid crystal elemental device according to the present invention. The liquid crystal elemental device thus obtained exhibited less color irregularity and excellent contrast, as compared with a conventional liquid crystal elemental device in which spacers having a diameter of 6 μm are dispersed.

EXAMPLE 2

A metal chromium film having a thickness of 0.1 μm was formed on a glass substrate by sputtering and etched using a photoresist, thereby obtaining a lattice black matrix. Thereafter, a colored layer composed of colored patterns of R, G and B was formed using a publicly known process for forming a color filter by an ink-jet system. A protective layer composed of an acrylic resin was formed thereon by means of a spin coater to conduct smoothing. An ITO film as a transparent electrode was further formed thereon by sputtering. A curable, spacer-forming material having the following composition was ejected onto the black matrix of this substrate by an ink-jet head in the same manner as in EXAMPLE 1. Incidentally, an orientation film composed of polyimide was formed after the formation of the spacer.

Composition of curable, spacer-forming material:

Copolymer	10% by weight
Water	80% by weight
Ethylene glycol	10% by weight

The copolymer used in the above composition was a bipolymer of N,N-dimethylolacrylamide and methyl methacrylate (copolymerization ratio=40:60 by weight).

In this example, the curable, spacer-forming material was ejected 3 times to form the spacer. In this case, the spacer-forming material was ejected on the substrate in an amount of 20 ng for the first ejection, 15 ng for the second ejection and 10 ng for the third ejection, thereby forming a spacer in a substantially trapezoidal form as illustrated in FIG. 3.

The above-prepared substrate was heated at 100° C. for 15 minutes and then at 200° C. for 30 minutes to cure the curable, spacer-forming material, thereby forming the spacer. The spacer had a thickness of 5 μm and a diameter of about 20 μm.

The substrate on which the spacer had been formed and a substrate on which opposed electrodes had been formed were laminated with a sealant to fabricate a cell. A liquid crystal was filled into the cell to obtain a liquid crystal elemental device according to the present invention. The liquid crystal elemental device thus obtained exhibited less color irregularity and excellent contrast, as compared with a conventional liquid crystal elemental device in which spacers having a diameter of 6 μm are dispersed.

EXAMPLE 3

A metal chromium film having a thickness of 0.1 μm was formed on a glass substrate by sputtering and etched using a photoresist, thereby obtaining a lattice black matrix. Thereafter, a colored layer composed of colored patterns of R, G and B was formed using a publicly known process for forming a color filter by an ink-jet system. A protective layer composed of an acrylic resin was formed thereon by means of a spin coater to conduct smoothing. An ITO film as a

transparent electrode was further formed thereon by sputtering. A curable, spacer-forming material having the following composition was ejected onto this substrate at a position opposed to each element of the black matrix by an ink-jet head. In this example, an ink-jet head that can eject the spacer-forming material in a larger amount than the ink-jet head used in EXAMPLE 1 was used.

Composition of curable, spacer-forming material:

Copolymer	10% by weight
Water	80% by weight
Ethylene glycol	10% by weight

The copolymer used in the above composition was a bipolymer of N,N-dimethylolacrylamide and methyl methacrylate (copolymerization ratio=40:60 by weight).

The above-prepared substrate was heated at 100° C. for 15 minutes and then at 200° C. for 30 minutes to cure the curable, spacer-forming material, thereby forming a spacer.

The top of the cured spacer was then abraded by such an abrading device as illustrated in FIG. 4, thereby flattening the top into a flat surface having an average area of about 100 μm^2. The height of the spacer was controlled to 5 μm.

The spacer-bearing substrate, the spacer of which had been abraded, was immersed in an ultrasonic cleaning bath to apply an ultrasonic wave of 100 kHz and 250 W for 1 minute thereto, thereby cleaning the substrate. An orientation film was further formed thereon, followed by baking and a rubbing treatment.

The substrate on which the spacer had been formed and a substrate on which opposed electrodes had been formed were laminated with a sealant to fabricate a cell. A liquid crystal was filled into the cell to obtain a liquid crystal elemental device according to the present invention. The liquid crystal elemental device thus obtained exhibited less color irregularity and excellent contrast, as compared with a conventional liquid crystal elemental device in which spacers having a diameter of 6 μm are dispersed.

EXAMPLE 4

A resin composition comprising 97 parts by weight of an acrylic terpolymer having the following composition and 3 parts by weight of triphenylsulfonium hexafluoroantimonate dissolved in ethyl cellosolve was applied onto a glass substrate, on which a lattice black matrix (aperture size: 60 μm×150 μm) having a width of 20 μm and a length of 35 μm had been formed with chromium by spin coating so as to give a film thickness of 2 μm, followed by prebaking at 90° C. for 20 minutes, thereby forming an ink-receiving layer.

Composition of acrylic terpolymer:

methyl methacrylate	50 parts by weight
hydroxyethyl methacrylate	30 parts by weight
N-methylolacrylamide	20 parts by weight

The ink-receiving layer was subjected to patterning exposure in stripe form at part of the ink-receiving layer on the black matrix through a photomask having stripe openings, each having a width narrower than that of the black matrix, and then subjected to a heat treatment for 1 minute on a hot plate heated to 120° C. Dye inks of R (red), G (green) and B (blue) colors were applied to unexposed portions of the ink-receiving layer by means of an ink-jet recording apparatus, thereby coloring the ink-receiving layer in stripe form with continuous dots. The inks were then dried at 90° C. for 5 minutes. The substrates thus colored were subsequently subjected to a heat treatment at 200° C. for 60 minutes to cure the whole ink-receiving layer, thereby obtaining a colored layer.

A two-pack type thermosetting resin composition ("SS6699G", trade name, product of JSR Co., Ltd.) was spin coated on the colored layer so as to give a film thickness of 1 μm and prebaked at 90° C. for 30 minutes. The thus-formed film was heat treated at 250° C. for 60 minutes to form a protective layer. An ITO film was then formed by sputtering so as to give a thickness of 1,500 Å, thereby obtaining a color filter.

Beads (divinylbenzene-crosslinked polystyrene; specific gravity: 1.02) having a particle diameter of 5.5 μm were dispersed in an adhesive (specific gravity: 0.98) composed of 10% by weight of a bipolymer of N,N-dimethylolacrylamide and methyl methacrylate (weight ratio=40:60), 80% by weight of water and 10% by weight of ethylene glycol in such a manner that the content of the beads in a spacer-forming material was 10% by weight, thereby preparing a bead-containing spacer-forming material. The viscosity of this spacer-forming material was 19 cp at 25° C. The bead-containing spacer-forming material was applied onto the ITO film by an ink-jet head in such a manner that the beads were partially arranged in a region overlapping with the black matrix. The beads were uniformly dispersed in the spacer-forming material in this application step and have been applied to desired positions on the black matrix. The thus-treated substrate was subjected to an additional heat treatment at 150° C. for 20 minutes to cure the adhesive, thereby fixing the beads to the ITO film to obtain a spacer-bearing color filter.

The spacer-bearing color filter thus obtained was used to fabricate a liquid crystal elemental device for color display. As a result, a good color image was displayed.

EXAMPLE 5

A resin composition comprising 97 parts by weight of an acrylic terpolymer having the following composition and 3 parts by weight of triphenylsulfonium hexafluoroantimonate dissolved in ethyl cellosolve was applied onto a glass substrate, on which a lattice black matrix (aperture size: 100 μm×300 μm) having a width of 20 μm and a length of 40 μm had been formed with chromium by spin coating so as to give a film thickness of 2 μm and prebaked at 90° C. for 20 minutes, thereby forming an ink-receiving layer.

Composition of acrylic terpolymer:

methyl methacrylate	50 parts by weight
hydroxyethyl methacrylate	30 parts by weight
N-methylolacrylamide	20 parts by weight

The ink-receiving layer was subjected to patterning exposure in stripe form at part of the ink-receiving layer on the black matrix through a photomask having stripe openings, each having a width narrower than that of the black matrix, and then subjected to a heat treatment for 1 minute on a hot plate heated to 120° C. Dye inks of R (red), G (green) and 8 (blue) colors were applied to unexposed portions of the ink-receiving layer by means of an ink-jet recording apparatus, thereby coloring the ink-receiving layer in stripe

form with continuous dots. The inks were then dried at 90° C. for 5 minutes. The substrates thus colored were subsequently subjected to a heat treatment at 200° C. for 60 minutes to cure the whole ink-receiving layer, thereby obtaining a colored layer.

A two-pack type thermosetting resin composition ("SS 6699G", trade name, product of JSR Co., Ltd.) was spin coated on the colored layer so as to give a film thickness of 1 μm and prebaked at 90° C. for 30 minutes. The thus-formed film was heat treated at 250° C. for 60 minutes to form a protective layer. An ITO film was then formed by sputtering so as to give a thickness of 150 nm, thereby obtaining a color filter.

A spacer-forming material having the following composition was applied in an amount of 5 pl per position onto the color filter thus obtained in a region overlapping with the black matrix by an ink-jet system. The spacer-forming material thus applied was subjected to a heat treatment to cure.

Composition of curable, spacer-forming material:

Polypropylene/glycol diglycidyl ether ("EX-920", product of Nagase Chemicals, Ltd.)	80% by weight
Water	20% by weight

The spacer thus obtained was in a substantially cylindrical form having a diameter of 20 μm and a height of 5 μm.

The spacer-bearing color filter thus obtained was used to fabricate a liquid crystal elemental device. As a result, no influence of the spacer on display was exerted, and so a good display was realized.

What is claimed is:

1. A process for producing a liquid crystal elemental device comprising a pair of substrates arranged in opposed relation to each other through a spacer and a liquid crystal held in a space between the substrates, said process comprising the steps of:

applying a spacer-forming material onto one of the pair of substrates by an ink-jet system to form the spacer,

arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and

enclosing a liquid crystal compound in the space between the pair of substrates,

wherein the spacer-forming material comprises an adhesive and beads dispersed in the adhesive, and

wherein a ratio of the specific gravity of the beads to the specific gravity of the adhesive is 0.9 to 1.1.

2. A process for producing a liquid crystal elemental device comprising a pair of substrates arranged in opposed relation to each other through a spacer and a liquid crystal held in a space between the substrates, said process comprising the steps of:

applying a spacer-forming material onto one of the pair of substrates by an ink-jet system to form the spacer,

arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and

enclosing a liquid crystal compound in the space between the pair of substrates,

wherein the spacer-forming material comprises an adhesive and beads dispersed in the adhesive, and

wherein the beads have a particle diameter of 0.8 to 10 μm, and the adhesive has a viscosity of 2 to 100 cp at 25° C.

3. A process for producing a liquid crystal elemental device comprising a pair of substrates arranged in opposed relation to each other through a spacer and a liquid crystal held in a space between the substrates, said process comprising the steps of:

applying a spacer-forming material onto one of the pair of substrates by an ink-jet system to form the spacer,

arranging the pair of substrates in opposed relation to each other with the spacer held therebetween, and

enclosing a liquid crystal compound in the space between the pair of substrates,

wherein the spacer-forming material comprises a curable component curable by light or heat and a solvent component, and the content of the solvent component is at most 50% by weight.

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